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प्रथमो भागः

एकादशवर्गीय संस्कृतस्य पाठ्यपुस्तकम्

(विज्ञानवाणिज्य-छात्रेभ्यः)

संपादक

डॉ० कमलाकान्त मिश्र

राष्ट्रीय शैक्षिक अनुसंधान और प्रशिक्षण परिषद्

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पुरोवाक्

अस्माकं शिक्षाव्यवस्थायां संस्कृतस्य ज्ञान-विज्ञान-महत्त्वं स्वीकृत्य विद्यालयेषु संस्कृतशिक्षणार्थम् आदर्शपाठ्यक्रम-पाठ्यपुस्तकादीनां विकासक्रमे राष्ट्रियशैक्षिकानुसंधानप्रशिक्षणपरिषदः सामाजिकविज्ञान- मानविकी-शिक्षा-विभागेन षष्ठकक्षातः द्वादशकक्षापर्यन्तं नवीनराष्ट्रियपाठ्यचर्यानुरूपम् आदर्शपाठ्यक्रमं निर्माय संस्कृतपाठ्यपुस्तकानि विकास्यन्ते। अस्मिन्नेव क्रमे विज्ञानवाणिज्याधीयमानानां एकादशवर्गीयच्छात्राणां कृते प्रमुखेभ्यः संस्कृतग्रन्थेभ्यः गद्यपद्यनाटकमयान् उपयुक्तानंशान् सङ्कलय्य भूमिका-टिप्पण्यादिना समलङ्कृत्य प्रस्तूयतेऽधुना ***संस्कृतमन्दाकिनी (प्रथमो भागः)*** नामधेयं नूतनपुस्तकमिदम्।

संस्कृतभाषाज्ञानेन सह छात्रेभ्यः आयुर्विज्ञानम्, खगोलविज्ञानम्, ऋतुविज्ञानम्, रसायनविज्ञानम्, गणितशास्त्रम् इत्यादिषु विविधवैज्ञानिकविषयेषु वाणिज्यविषयेऽपि च प्राचीनभारतीयमनीषिणां मौलिकचिन्तनस्य तेषां विशिष्टयोगदानस्य च परिचयं प्रदातुं पुस्तकस्यास्य उद्देश्यं वर्तते। छात्रेषु जीवनमूल्यविकासाय अपेक्षितसुभाषितादिसामग्री अपि अत्र समाविष्टा।

अस्य पुस्तकस्य निर्माणे येषां विदुषाम् अनुभविनाम् अध्यापकानां च सहयोगः प्राप्तः, तान् प्रति परिषदियं हार्दिक्यं कार्तज्ञ्यं प्रकटयति। पुस्तकं उपयुक्ततरं विधातुं विदुषाम् अध्यापकानां परामर्शाः सदैव अस्माकं स्वागतार्हाः भवेयुः।

जगमोहनसिंहराजपूतः

निदेशकः

राष्ट्रियशैक्षिकानुसंधानप्रशिक्षणपरिषद्

नवदेहली

जनवरी, 2002

पाठ्य-पुस्तक-निर्माण-समिति

पाठ्यसामग्री-निर्माण-समिति

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भूमिका

संस्कृत भाषा एवं उसका वाङ्मय प्रारंभ से ही भारतीय संस्कृति एवं ज्ञान-विज्ञान का आधार रहा है। यह गंभीर शास्त्रज्ञान पारलौकिक चिंतन तथा वैज्ञानिक विवेचन का एकमात्र स्रोत है। वेद, वेदांग, दर्शन, धर्मशास्त्र, नीति और व्यवसाय जैसे सर्वांगीण विषयों और सार्वजनीन तथ्यों को ऐहिक और पारलौकिक उपलब्धियों की दृष्टि से जितना संस्कृत साहित्य में एकत्र प्रस्तुत किया गया उतना अन्यत्र भाषा-साहित्य में नहीं मिलता। इसकी सबसे बड़ी विशेषता यह रही है कि एक ओर जहाँ इसमें मानवीय संवेदना से जुड़कर काव्य की रचनाएँ हुईं वहीं दूसरी ओर विज्ञान और शास्त्रविमर्श से जुड़ी चिंतनधाराएँ भी समानांतर स्तर पर विद्वानों की लेखनी से विकसित हुईं। काव्य, नाटक तथा खगोलविज्ञान, ऋतुविज्ञान, रसायन, आयुर्वेद जैसे वैज्ञानिक विषयों का भी पल्लवन संस्कृत कविता के माध्यम से होता रहा। यहाँ तक कि जीवन-मूल्यों, वैज्ञानिक तथ्यों, वाणिज्यिक सिद्धांतों और आर्थिक, राजनैतिक विमर्शों पर भी संस्कृत की विविध विधाओं में रचनाएँ हुईं जिनमें चिंतन की गहराई है एवं समस्त मानवता के लिए कल्याणकारी कामना है।

संस्कृत का महत्त्व भारत में ही नहीं बल्कि विदेशों में भी स्वीकार कर लिया गया है। संस्कृत का भाषावैज्ञानिक धरातल इनमें अन्यतम कारण है। भारोपीय भाषाओं ने बहुत सारे शब्दों को आत्मसात् कर लिया है, जिनकी व्युत्पत्ति जानने के लिए संस्कृत भाषा का अनुशीलन अपेक्षित है।

राष्ट्रीय एकता की दृष्टि से भी संस्कृत भाषा और इसके वाङ्मय का महत्त्व श्लाघनीय है। मानवीय मूल्यों के संरक्षण और भारतीय अस्मिता के संवर्धन के लिए संस्कृत के अध्ययन के महत्त्व का अनुभव सभी करते हैं।

प्रस्तुत संकलन

संस्कृत वाङ्मय में अति प्राचीन काल से ललित साहित्य एवं जीवनमूल्यों के साथ-साथ विविध वैज्ञानिक ज्ञान गणित, रसायनशास्त्र, भौतिकशास्त्र, खगोलविज्ञान, आयुर्वेद, यंत्रविज्ञान, भूगर्भशास्त्र, वास्तुशास्त्र, अर्थशास्त्र, वाणिज्य आदि से सम्बद्ध प्रचुर सामग्री उपलब्ध है जो आज भी नितांत उपादेय है। उच्चतर माध्यमिक स्तर पर संस्कृतशिक्षण कलावर्ग तक सीमित है। परिणामतः विज्ञान एवं वाणिज्य के छात्र संस्कृत में निहित वैज्ञानिक ज्ञान की परम्परा से वंचित रह जाते हैं। इस कमी को दूर करने के लिए राष्ट्रीय शैक्षिक अनुसंधान और प्रशिक्षण परिषद् ने मानव संसाधन विकास मंत्रालय, भारत सरकार की प्रेरणा से केन्द्रीय विद्यालय संगठन एवं केन्द्रीय माध्यमिक शिक्षा बोर्ड से संबद्ध विद्यालयों के विज्ञान एवं वाणिज्य पढ़ने वाले उच्चतर माध्यमिक स्तर के छात्रों के लिए ऐच्छिक संस्कृत का एक विशेष पाठ्यक्रम तैयार किया है। परिषद् द्वारा प्रकाशित 'विद्यालयीय शिक्षा के लिए राष्ट्रीय पाठ्यचर्या की रूपरेखा' 2000 के आलोक में विकसित नवीन पाठ्यक्रम की अपेक्षाओं को ध्यान में रखते हुए उच्चतर माध्यमिक स्तर पर छात्रों को संस्कृत की व्यापक वैज्ञानिक एवं वाणिज्यिक चिंतन-परंपरा से परिचित कराने के लिए विशेषज्ञों एवं अनुभवी अध्यापकों द्वारा प्रदत्त परामर्श के अनुसार ग्यारहवीं कक्षा के विज्ञान एवं वाणिज्य के छात्रों के लिए ***संस्कृत-मंदाकिनी (प्रथमो भागः)*** नामक नवीन पाठ्यपुस्तक प्रस्तुत है।

ग्रंथ का उद्देश्य संस्कृत के ललित साहित्य एवं जीवन-मूल्य विषयक सूक्तियों के साथ ज्योतिर्विज्ञान, रसायनविज्ञान, ऋतुविज्ञान, आयुर्विज्ञान, खगोलविज्ञान तथा वाणिज्य से संबंधित विषयों से छात्रों को परिचित कराना है। भाषा-कौशल के समुचित विकास के लिए अपेक्षित सामग्री के साथ-साथ विज्ञान एवं प्रौद्योगिकी के क्षेत्र में भारतीय मनीषियों के मौलिक-चिंतन एवं विशिष्ट योगदानों से छात्रों को परिचित कराना इस संकलन का उद्देश्य है। साथ ही राष्ट्रीय-गौरव की भावना को विकसित करना भी इसका अन्यतर लक्ष्य है। इस लक्ष्य की पूर्ति के लिए वेद, उपनिषद्, नीति, रामायण, महाभारत, नाटक, आयुर्वेद, दर्शन, ज्योतिर्विज्ञान एवं अर्थशास्त्र से संबद्ध प्रतिनिधिभूत ग्रंथों से सामग्री संकलित की गई है।

इस पाठ्यपुस्तक में सामग्री-संकलन दो दृष्टियों से किया गया है। प्रथमतः परंपरागत रूप में प्रचलित वेद, उपनिषद्, महाभारत, नाटक आदि से व्यवहारोपयोगी

अंशों का संकलन किया गया है। उनमें भी ध्यान यह रखा गया है कि प्रदत्त प्रसंग में पर्यावरण, विज्ञान, आयुर्वेद जैसे जीवनोपयोगी विषयों की विवेचना हो। पुस्तक का दूसरा पक्ष सृष्टिविज्ञान, ज्योतिर्विज्ञान, रसायनविज्ञान, आयुर्विज्ञान जैसे वैज्ञानिक तथा वाणिज्यिक तथ्यों को प्रस्तुत करता है जिनका स्रोत संस्कृतसाहित्य है। ये समस्त ग्रंथ प्रायः पद्यबद्ध हैं। तर्कसंग्रह तथा अर्थशास्त्रप्रभृति कुछ ग्रंथ गद्य खण्डों में भी उपनिबद्ध हैं।

मूलतः इस पुस्तक का संकलन संस्कृत के वैज्ञानिक साहित्य की ओर छात्रों की उत्सुकता बढ़ाने के निमित्त हुआ है। वन्दना की सामग्री, ईश की व्यापकता, राष्ट्र की समृद्धि, समता तथा पर्यावरण विषयक चेतना को जागरूक करती है। **सूक्तिसुधा** का कथ्य जीवन को व्यवस्थित तथा उन्नतिशील बनाने की प्रेरणा देता है। रामायण से संकलित पाठ्यांश मंत्रियों, सैनिकों तथा मंत्रणा की दिशा को उद्भासित करता है। महाभारत से ली गई सामग्री युधिष्ठिर और भीष्म पितामह के मध्य का संवाद है जिसमें भाग्य और कर्म में कौन प्रधान है — इस पर प्रकाश डाला गया है।

आश्रमजीवनम् पाठ वन में रहने वाले मुनियों के मनस्वी तथा तेजस्वी जीवन पर प्रकाश डालता है। **पंचमहाभूतानि** पाठ्यांश तर्कसंग्रह से संकलित है जिसमें पृथ्वी, जल, तेज, वायु तथा आकाश का विवरण बड़ी सूक्ष्मता से दिया गया है। शेष पाठ संस्कृत के वैज्ञानिक साहित्य से संबद्ध हैं।

इस संकलन में वन्दना के अतिरिक्त कुल ग्यारह पाठ हैं। वन्दना में कुल तीन वैदिक सूक्तियाँ हैं जिनमें एक ऋग्वेद से तथा शेष दो सूक्तियाँ यजुर्वेद से ली गई हैं। इनमें से एक मंत्र यजुर्वेद तथा ईशोपनिषद् दोनों में समान है। प्रथम सूक्ति में ईश की व्यापकता, द्वितीय में समता एवं समरसता तथा तृतीय में पर्यावरण के शांतिप्रद होने की प्रार्थना की गई है।

संकलन के स्रोत

प्रस्तुत पाठ्यपुस्तक में संकलित अंशों को मुख्यतः दो भागों में बाँटा गया है। प्रथम चार पाठों का स्रोत वेद, उपनिषद्, कथासाहित्य, रामायण, महाभारत और नाटक हैं जो संस्कृत का साहित्यिक पक्ष है। शेष पाठों का स्रोत संस्कृत का वैज्ञानिक और वाणिज्य संबंधी साहित्य है। जिन प्रतिनिधि आचार्यों या ग्रंथों से ये

पाठ्यांश संगृहीत हैं उनका सामान्य परिचय इस प्रकार है :

वेद : वेद विश्व का प्राचीनतम साहित्य और विशालतम ज्ञान-भंडार है। इसमें धर्म से लेकर आचार तक, कला से लेकर व्यापार तक और नीति और व्यवहार से लेकर अध्यात्म तक के समस्त विषय वर्णित हैं। इसीलिए वेद ज्ञान है, वेद विचार है, वेद अस्तित्व है और वेद उपलब्धि है – ऐसा निर्वचनकारों का मत है। महर्षि कृष्ण द्वैपायन व्यास ने इसे चार भागों में संकलित किया – ऋग्वेद, यजुर्वेद, सामवेद और अथर्ववेद। ऋग्वेद में पद्यात्मक आर्षवाणी का संकलन है। इसमें कुल दस मंडल, 1028 सूक्त तथा 10580 ऋचाएँ हैं। यजुर्वेद गद्यप्रधान है। यह यज्ञकर्म के लिए प्रसिद्ध है। इसकी दो प्रमुख शाखाएँ हैं– शुक्ल-यजुर्वेद और कृष्ण-यजुर्वेद। शुक्ल यजुर्वेद में 85 शाखाएँ हैं जिसमें वाजसनेयी शाखा के अंतर्गत काण्व शाखा प्राप्त है। शुक्ल यजुर्वेद में अध्याय एवं कंडिकाओं के रूप में मंत्र संगृहीत हैं। यजुर्वेद की तैत्तिरीयशाखा मण्डल, वल्ली और कंडिकाओं में विभक्त है।

नीति : संस्कृत भाषा में नीतिविषयक साहित्य का विशाल भंडार है। प्रस्तुत पाठ **नीतिसुधा** में चाणक्यनीति तथा हितोपदेश से कुछ पद्य संकलित हैं। चाणक्य को चाणक्यनीति का निर्माता माना जाता है। अर्थशास्त्र के लेखक विष्णुगुप्त कौटल्य चाणक्यनीति के भी निर्माता हैं। ये कुटल गोत्र में उत्पन्न हुए थे इसलिए इन्हें कौटल्य कहते हैं। कुटिल नीतियों के निर्माता होने के कारण इन्हें कौटिल्य भी कहते हैं।

हितोपदेश : हितोपदेश के प्रणेता नारायण हैं और सुदर्शन नामक राजा के मूर्ख पुत्रों को पढ़ाने वाले पंडित विष्णुशर्मा इसमें एक पात्र हैं। इस ग्रंथ में पशु-पक्षी और मनुष्यों की कथाओं के द्वारा उपदेश किया गया है। सरल उदाहरण देकर बालकों की शिक्षा के लिए इस ग्रंथ का निर्माण हुआ है। इस ग्रंथ से भी कुछ पद्य उक्त पाठ में संकलित हैं जो अत्यंत शिक्षाप्रद हैं।

रामायण : रामायण, आदिकवि वाल्मीकि की रचना है इसीलिए आदिकाव्य है। इसका रचनाकाल सामान्यतः बुद्ध से पूर्व माना जाता है। रामायण में कुल सात कांड हैं– बालकांड, अयोध्याकांड, अरण्यकांड, किष्किन्धाकांड, सुन्दरकांड, युद्धकांड एवं उत्तरकांड। प्रस्तुत पाठ्यांश, अयोध्याकांड के सौवें सर्ग से संगृहीत है।

महाभारत : इसकी रचना महर्षि व्यास ने की है। महाभारत का रचनाकाल भी सामान्यतः बुद्ध से पूर्व माना जाता है। कतिपय विद्वान् इसको रामायण का समकालीन कहते हैं। महाभारत में कुल अठारह पर्व हैं— आदिपर्व, सभापर्व, वनपर्व, विराटपर्व, उद्योगपर्व, भीष्मपर्व, द्रोणपर्व, कर्णपर्व, शल्यपर्व, सौप्तिकपर्व, स्त्रीपर्व, शांतिपर्व, अनुशासनपर्व, आश्वमेधिकपर्व, आश्रमवासिकपर्व, मौसलपर्व, महाप्रस्थानिकपर्व एवं स्वर्गारोहणपर्व।

इस ग्रंथ में कौरव-पांडवों की उत्पत्ति से लेकर पाण्डवों के स्वर्ग जाने तक का वर्णन है। महाभारत में एक लाख श्लोक हैं इसलिए इसे **शतसाहस्रीसंहिता** भी कहते हैं। संपूर्ण संहिता व्यास द्वारा रचित है जिसके कारण यह **वैयासिकसंहिता** के नाम से भी प्रसिद्ध है। प्रस्तुत पाठ्यपुस्तक का पाठ्यांश अनुशासनपर्व के छठे अध्याय से लिया गया है।इसमें युधिष्ठिर एवं भीष्मपितामह का परस्पर संलाप है जहाँ कर्म तथा भाग्य दोनों में कौन श्रेष्ठ है? इस पर विवेचन किया गया है।
नाटककार भास : संस्कृत का नाट्य-साहित्य अत्यंत विपुल है और मुख्य नाटककारों में भास अन्यतम हैं। कालिदास और बाण ने भास को आदरपूर्वक स्मरण किया है। भास का समय सामान्यतः 300 ई०पू० माना जाता है। भास प्रणीत 13 नाट्य-कृतियाँ हैं— प्रतिमा, अभिषेक, बालचरित, पंचरात्र, मध्यमव्यायोग, दूतवाक्य, दूतघटोत्कच, कर्णभार, ऊरुभंग, स्वप्नवासवदत्त, प्रतिज्ञायौगन्धरायण, अविमारक और चारुदत्त नाटक। प्रस्तुत पाठ्यांश भास के सर्वाधिक प्रसिद्ध नाटक **स्वप्नवासवदत्तम्** के प्रथम अंक से संगृहीत है जिसमें प्राचीन भारत के आश्रमवासी मुनियों के मनस्वी जीवन तथा आश्रमपरिवेश पर उत्तम प्रकाश पड़ता है। यह पाठ पर्यावरण की दृष्टि से भी महत्त्वपूर्ण है।
तर्कसंग्रह : संस्कृत साहित्य में तर्कविज्ञान का विपुल भंडार है। तर्कसंग्रह, तर्कविज्ञान का एक प्रारंभिक सरल प्रकरण ग्रंथ है। इसके रचयिता अन्नंभट्ट हैं। इनका समय 17वीं शताब्दी है। इस ग्रंथ से संगृहीत पाठ में पाँच महाभूतों का वैज्ञानिक परिचय दिया गया है। पृथ्वी, जल, तेज, वायु तथा आकाश पंचमहाभूत हैं। इनमें प्रथम चार में से प्रत्येक के पाँच भेद बताए गये हैं। पाँचवाँ महाभूत आकाश एक ही प्रकार का माना गया है।

पाठ के प्रारंभ में महाभूतों का लक्षण दिया गया है तदनन्तर उनके भेद कहे गये हैं। उसके बाद प्रत्येक के नित्य एवं अनित्य पक्ष को समझाया गया है।

इसके पश्चात् इन चार महाभूतों के शरीर , इन्द्रिय और विषय के भेद से तीन-तीन प्रकार बताये गये हैं। इन भेदों का विवेचन बड़ा ही वैज्ञानिक है क्योंकि इन चार महाभूतों के शरीर को उन-उन महाभूतों के मुख्य लोकों में दिखाया गया है। यथा– पृथ्वी का शरीर प्राणियों के शरीर में बताया गया है। इसी तरह जल के शरीर को वरुण लोक में बताया गया है। तेज का शरीर आदित्य लोक में है और वायु का शरीर वायुलोक में है। इन्द्रियभेद का वर्णन करते हुए कहा गया है कि पृथ्वी का इन्द्रियमूलक भेद प्राणियों की नासिका में है, जल का इन्द्रियमूलक भेद जिह्वा के अग्रभाग में, तेज का इन्द्रियमूलक भेद प्राणियों के नेत्र की कनीनिका में तथा वायु का इन्द्रियमूलक भेद प्राणियों के त्वक् (चर्म) में स्थित है।

इसी प्रकार पृथ्वी का विषयमूलक भेद मिट्टी पाषाण आदि, जल का नदी, समुद्र, सरोवर आदि, तेज का स्वर्ण आदि एवं वायु का विषयमूलक भेद वृक्ष आदि के रूप में उपस्थित है। इन विभाजनों में महाभूतों के शरीर को उनके मुख्य स्थान में दिखाया गया है। इन्द्रिय वाले अंश को इस तरह दिखाया गया है कि प्राणियों की इन्द्रियों पर इनका क्या प्रभाव पड़ता है। विषयरूप में इन्हें उन विषयों पर दिखाया गया है, जिन अचेतन तत्त्वों पर उनका प्रभाव पड़ता है। इस प्रकार यह पाठ दर्शन के पाँच महाभूतों का तर्कपूर्ण वैज्ञानिक प्रतिपादन है।

प्रस्तुत संकलन में संस्कृत का वैज्ञानिक साहित्य

'विज्ञान' शब्द वि उपसर्ग पूर्वक ज्ञा धातु से ल्युट् प्रत्यय जुड़ने से निष्पन्न हुआ है जिसका तात्पर्य विशेष रूप से किसी भी ज्ञान की विधा को क्रमबद्ध जानना है। इस प्रकार विज्ञान की परंपरा में प्रत्यक्ष रूप से सांसारिक या लौकिक ज्ञान को अथवा सांसारिक अनुभव से प्राप्त ज्ञान को विशेष रूप से परख कर उसकी आलोचना, विवेचना तथा उसे प्रयोग की कसौटी पर कसा जाता है। ऐसी भ्रांत अवधारणा जनमानस के मन एवं मस्तिष्क पर बैठी हुई है कि विज्ञान के आकर्षक चमत्कार पाश्चात्य सभ्यता और आधुनिक खोजों की ही देन हैं। वस्तुतः ऐसा नहीं हैं।

सुदूर प्राचीन वैदिक काल से ही यत्र-तत्र प्रयोगात्मक विज्ञान के बिंदु, वेदों, ब्राह्मण-ग्रंथों तथा उपनिषदों में मिलते हैं, लेकिन शास्त्रों के रूप में भी संस्कृत भाषा-परंपरा में रची गयी विज्ञान की परंपरा प्राचीन सिद्ध होती है, जिससे

न केवल भारतीय विद्वान् अपितु Colebrooke, G.Thibaut, Burgess आदि विद्वान् भी सहमत हैं। शास्त्र के रूप में — खगोलशास्त्र, गणितशास्त्र, रसायनशास्त्र, चिकित्साशास्त्र, वास्तुशास्त्र, भूगर्भशास्त्र, मानवविज्ञान, अर्थशास्त्र, वाणिज्य आदि न केवल विज्ञान की एक-एक अध्ययन विधा रह गये थे अपितु शास्त्रों के रूप में सर्वप्रसिद्धि को प्राप्त कर चुके थे। वराहमिहिर, आर्यभट, भास्कराचार्य, चरक, माधव, सुश्रुत, कौटिल्य आदि विश्वविख्यात विज्ञान-विषयक विद्वान् थे।

इसी गौरवशाली परंपरा का विद्यार्थियों को कुछ परिचय मिल सके तथा उनमें विश्लेषणात्मक बुद्धि उत्पन्न हो, प्राचीन भारतीय पद्धतियों का सामंजस्य, वे आज के विज्ञान से स्थापित कर सकें, इसलिए इस पुस्तक में चार वैज्ञानिक तथा दो वाणिज्य-संबंधी पाठों का संकलन किया गया है। उनकी पृष्ठभूमि में जो मूल ग्रंथ रहा है, उसका संक्षिप्त परिचय इस प्रकार है :

सूर्यसिद्धांत : *आज* उपलब्ध सूर्यसिद्धान्त में 14 अधिकार और सब मिलाकर अनुष्टुप् छंद के 500 श्लोक हैं। इनमें भगणादि के मान आरंभ में दिए गये हैं, *जिनसे ज्ञात होता है कि कृतयुग के अंत* में सूर्य की *आज्ञा से* सूर्यांशभूत पुरुष ने मय नामक असुर को यह सिद्धांत बताया अर्थात् शक संवत् 1817 के आरंभ में इसे बने 21,64,996 वर्ष हो गए। इसमें समय की इकाइयों का सूक्ष्म वर्णन, ग्रहों के मध्य तथा स्पष्ट गतियों की आनयन विधि, सूर्य व चंद्रग्रहण के मान के प्रकार तथा भूगोलादि का सुंदर व स्पष्ट विवरण मिलता है।

भारतीय खगोलशास्त्र की परंपरा में इसे एक आर्षग्रंथ की संज्ञा दी जाती है। **ब्रह्माण्डविज्ञानम्** उक्त ग्रंथ से संगृहीत पाठ्यांश है। ब्रह्मांडविज्ञान का विमर्श, पुराण ज्योतिर्विज्ञान एवं खगोलशास्त्र के ग्रंथों में विस्तृत रूप से प्राप्य है। इस पाठ में जहाँ ब्रह्मांड के मूल स्रोत को अद्वितीय ब्रह्म माना गया है वहीं इसमें विभिन्न ग्रहों, तारामंडल, भूलोकादि तथा ग्रह कक्षा का वर्णन भी किया गया है।

चरकसंहिता : आयुर्विज्ञान से संबद्ध संस्कृत भाषा में विशाल साहित्य उपलब्ध है। *इन ग्रंथों में* चरकसंहिता *का अति महत्त्वपूर्ण स्थान है। कहा गया है कि महर्षि* पतंजलि का नाम चरक भी था। इनके संबंध में निम्नलिखित श्लोक प्रसिद्ध है:

योगेन चित्तस्य पदेन वाचां मलं शरीरस्य च वैद्यकेन।
योऽपाकरोत्तं प्रवरं मुनीनां पतञ्जलिं प्राञ्जलिरानतोऽस्मि।।

ऋतुचर्या इसी ग्रंथ से संकलित है। स्वस्थ जीवन एवं आवश्यकतानुकूल कार्य के लिए समय के अनुकूल आहार की दिनचर्या अगर बरती जाय तो व्यक्तिगत रोग एवं तज्जन्य पारिवारिक तथा सामाजिक परेशानियों से बचते हुए कार्य-संपादन किया जा सकता है।

भास्कराचार्य : भास्कराचार्य भारतीय गणितशास्त्र तथा ज्योतिर्विज्ञान की परंपरा में अद्वितीय विद्वान् थे जिनकी कीर्ति न केवल भारत में अपितु विश्व में फैली हुई थी। इन्होंने अपना जन्म स्थान सह्याद्रि पर्वत के निकट **विज्जडविड** ग्राम बताया है परंतु यह पता नहीं कि इसका वर्तमान नाम क्या है ? इन्होंने अपना जन्मकाल तथा ग्रंथनिर्माणकाल स्पष्ट भाषा में लिखा है। इनका जन्म 1114 ई० में हुआ और 36 वर्ष की आयु में इन्होंने **सिद्धान्तशिरोमणि** जैसे बृहत्काय ग्रंथ की रचना की।

सिद्धान्तशिरोमणि ग्रंथ के दो भाग हैं – *1. गणिताध्याय तथा 2. गोलाध्याय।* **ग्रहगणित** में पाटीगणित, अंकगणित, महत्त्वमापन (क्षेत्रफल, घनफल आदि का) बीजगणित, भिन्नपरिकर्माष्टक आदि अनेक गणितीय विधियाँ स्पष्ट की गयी हैं। गोलाध्याय भास्कराचार्य की बौद्धिक प्रगल्भता का मूर्तरूप है। इसमें गोल की प्रशंसा, भूकेन्द्रित होकर खगोल का विवेचन, ज्योत्पत्ति, त्रिप्रश्न में दिशा-देश-काल आदि का ग्रहण, ग्रहों के उदय एवं अस्त का विवेचन, ऋतुवर्णन, यन्त्रविज्ञान तथा खगोलीय प्रश्नों का समाधान किया गया है। भास्कराचार्य ने स्वरचित पद्यात्मक गणित सिद्धांतों को स्पष्ट करने के लिए **वासनाभाष्य** नामक व्याख्या स्वयं की है।

गणितविधि लीलावती नामक ग्रंथ से संगृहीत है। भास्कराचार्य की यह पुस्तक लीलावती बालकों के लिए रचा गया संस्कृत में गणितशास्त्र का महत्त्वपूर्ण अंश है। कहा जाता है कि भास्कराचार्य ने अपनी व्युत्पन्नमति पुत्री लीलावती को संबोधित करके यह ग्रंथ लिखा है। इसमें प्रश्नोत्तर के रूप में पाटीगणित या अंकगणित (Arithmatic) क्षेत्रमिति आदि के प्रश्न रोचक रूप में उठाये गये हैं। अंत में आये गणितपाठ क्रमचय नामक अध्याय की भाषा बहुत ही ललित है। इस पर संस्कृत व हिन्दी में अनेक टीकाएं प्रकाशित हो चुकी हैं।

प्राचीनयन्त्रविज्ञानम् सिद्धान्तशिरोमणि के गोलाध्याय से संगृहीत है। इसमें प्राचीन यंत्रों को समय की इकाई के आकलन और वेध की दृष्टि से निर्मित किया गया है। वस्तुतः प्रत्यक्ष, जो आँख से आकाश में दिखाई पड़ता है और वेध, जो गणित के सिद्धांत पर गणना में आता है, उनमें प्राप्त अंतर को यंत्रों से परीक्षित किया जाता है। वेधशाला उन्हीं यंत्रों के संग्रह का स्थान है। यहाँ खगोलीय स्थितियों का वेध किया जाता है।

आचार्य कौटिल्य : आचार्य कौटिल्य एक पारंगत राजनीतिज्ञ, अर्थशास्त्री, और नीतिसम्राट् तथा मौर्यसाम्राज्य के विपुलयश-विस्तार के महानायक थे। अपनी अद्वितीय तथा अद्‌भुत कृतियों के कारण इन्हें संस्कृत साहित्य जगत् में अपने विषय का एकमात्र विद्वान् होने का गौरव प्राप्त है। सम्राट् चन्द्रगुप्त मौर्य ने विष्णुगुप्त नामक एक अद्‌भुत, कुटिलमति राजनीतिज्ञ ब्राह्मण की सहायता से मगध के नन्दवंश को विनष्ट कर तथा शक्तिशाली यवनराज सिकन्दर के प्रयत्नों को विफल कर लगभग 321ई० पूर्व में विराट् साम्राज्य की स्थापना की, जिसको मौर्य साम्राज्य कहते हैं। इनका एक लोकविश्रुत नाम चाणक्य है। चाणक्य उन्हें चणक का पुत्र होने के कारण और कौटिल्य उन्हें कुटिल राजनीतिज्ञ होने के कारण कहा जाता था। ये दोनों ही नाम इनके पितृप्रदत्त न होकर वंशनाम एवं उपाधिनाम हैं। इनका पितृप्रदत्त नाम विष्णुगुप्त था।

इन्होंने अर्थशास्त्र की रचना की जो अपने आप में एक विशेष एवं अनूठा ग्रंथ है। डा० शाम शास्त्री ने इसका अंग्रेजी अनुवाद तथा म०म०गणपति शास्त्री ने इसका संस्कृत अनुवाद कर इसे प्रामाणिक ग्रंथ बनाया है। इसमें पंद्रह अधिकरण हैं जिनका आरंभ विनयाधिकार से होकर प्रायः अर्थशास्त्र संबंधी सभी विषयों का पूर्ण विवेचन प्रस्तुत करता है। यथा — अध्यक्षप्रचार, दायविभाग, कण्टकशोधन, दण्डव्यवस्था, मण्डल-विवेचन, षाड्‌गुण्य का उद्देश्य, क्षय, स्थान एवं वृद्धि, अभियास्यत्कर्म, संग्राम एवं छावनियों की व्यवस्था, भेदकप्रयोग, दूतकर्म, दुर्गलम्भोपाय, शत्रुवध के प्रयोग। अंत में अर्थशास्त्र की युक्तियाँ दी गयी हैं।

भारतीय साहित्य परम्परा में यह अर्थशास्त्र, राजनीतिशास्त्र, तथा वाणिज्य के मिश्रण का अद्‌भुत ग्रंथ है।

शुल्क-व्यवहारः तथा व्यावसायिक-पत्र-व्यवहारः इसी ग्रंथ से संकलित अंश हैं। राष्ट्र की समृद्धि के लिए राजस्व की प्राप्ति आवश्यक है। इससे राजकीय एवं सार्वजनिक उपक्रमों की स्थापना एवं व्यवस्था होती है जिससे राष्ट्र में विभिन्न विकास के कार्य संपादित किये जाते हैं। राजस्व पर ही उत्पादन व्यवस्था और उत्पादनादि तथा उससे प्राप्त विभिन्न शुल्कों से राजव्यवस्था संपन्न होती है। प्रस्तुत पाठ प्राचीनकाल में देयशुल्कों की प्रक्रिया और व्यवस्था की ओर संकेत देता है।

व्यावसायिक-पत्र-व्यवहारः में राजप्रशासन या राजप्रमुख किस प्रकार की आज्ञा या अधिसूचना प्रकाशित करता था, इसका दिग्दर्शन इस पाठ में किया गया है। वाणिज्यिक प्रबंधन में पत्र का प्राचीन रूप क्या था – इस दृष्टि से यह पाठ महत्त्वपूर्ण है।

पुस्तक के आरंभ में दी गई भूमिका से तत्त्वमूलक, मंत्रणामूलक, पर्यावरणमूलक, विज्ञान एवं गणितमूलक तथा वाणिज्यमूलक ग्रंथों का संक्षिप्त ज्ञान कराया गया है, साथ ही संस्कृत के वैज्ञानिक साहित्य का भी एक संक्षिप्त परिचय दिया गया है।

पाठों के प्रारंभ में पाठ परिचय दिए गये हैं जिससे संकलित अंश का प्रसंग सरलतया छात्रों के लिए बोधगम्य हो सके। कक्षा में छात्रों का ज्ञान बढ़े, इसके लिए पाठों के अंत में शब्दार्थ एवं टिप्पणी तथा व्यापक अभ्यास-प्रश्न दिये गये हैं। इनमें अर्थबोध, विषय-वस्तु-विस्तार और व्याकरण आदि से संबद्ध प्रश्नों का समावेश किया गया है।

प्रस्तुत पुस्तक की पाण्डुलिपि की समीक्षा के लिए आयोजित कार्यगोष्ठियों में आकर जिन विषय-विशेषज्ञों एवं संस्कृत अध्यापकों का मार्गदर्शन एवं सहयोग सुलभ हुआ है, संपादक उन सभी विद्वानों के प्रति हृदय से आभारी है। यद्यपि इस संकलन को यथासंभव छात्रोपयोगी एवं स्तर के अनुरूप बनाने का प्रयत्न किया गया है, तथापि इसे छात्रों के लिए और अधिक उपादेय बनाने के लिए अनुभवी संस्कृत अध्यापकों के सुझावों का हम सदैव स्वागत करेंगे।

विषयानुक्रमणिका

गांधी जी का जन्तर

तुम्हें एक जन्तर देता हूं। जब भी तुम्हें सन्देह हो या तुम्हारा अहम् तुम पर हावी होने लगे, तो यह कसौटी आजमाओ :

जो सबसे गरीब और कमजोर आदमी तुमने देखा हो, उसकी शकल याद करो और अपने दिल से पूछो कि जो कदम उठाने का तुम विचार कर रहे हो, वह उस आदमी के लिए कितना उपयोगी होगा। क्या उससे उसे कुछ लाभ पहुंचेगा ? क्या उससे वह अपने ही जीवन और भाग्य पर कुछ काबू रख सकेगा ? यानि क्या उससे उन करोड़ों लोगों को स्वराज्य मिल सकेगा जिनके पेट भूखे हैं और आत्मा अतृप्त है ?

तब तुम देखोगे कि तुम्हारा सन्देह मिट रहा है और अहम् समाप्त होता जा रहा है।

मो॰ क॰ गांधी

वन्दना

ईशावास्यमिदं सर्वं यत्किंच जगत्यां जगत्।
तेन त्यक्तेन भुञ्जीथा मा गृधः कस्यस्विद्धनम्।।1।।

(यजुर्वेदः - 40/1) ईशोपनिषद्1

भावार्थ : सृष्टि में यह सब जो कुछ भी जड़ चेतन पदार्थ हैं वह ईश्वर से आवासित या आच्छादित हैं। अर्थात् सभी में ईश्वर का निवास है। अतः सभी लोग उस परमेश्वर के द्वारा दिए गए पदार्थों का ही परस्पर त्याग की भावना से भोग करें। किसी अन्य व्यक्ति के धन का लोभ न करें।।1।।

समानो मन्त्रः समितिः समानी समानं मनः सह चित्तमेषाम्।
समानं मन्त्रमभिमन्त्रये वः समानेन वो हविषा जुहोमि।।2।।

(ऋग्वेदः - 10/192/3)

भावार्थ : इस मंत्र में ईश्वर मानवमात्र के लिए प्रेरणा देते हैं कि सभी के विचार समान हों। समिति अर्थात् सभाएँ और उनमें बैठकर लिए गए निर्णय समान हों। सभी के मन अर्थात् संकल्प तथा चित्त अर्थात् चिंतन एक जैसे हों। मैं तुम सब को एक ही विचार से युक्त करता हूँ तथा सभी के लिए एक ही जैसे (समान भाव से) हवि अर्थात् अन्न आदि भोग्य पदार्थ प्रदान करता हूँ।

अभिप्राय यह है कि परमात्मा एवं प्रकृति की ओर से सभी को उपभोग के साधन समान भाव से दिए गए हैं। अतः विचारों की एकता, भोगों की समानता तथा समरसता में ही सुख है।।2।।

द्यौः शान्तिरन्तरिक्ष ७ शान्तिः पृथिवी शान्तिरापः
शान्तिरोषधयः शान्तिःवनस्पतयः शान्तिर्विश्वेदेवाः शान्तिर्ब्रह्म
शान्तिः सर्व ७ शान्तिःशान्तिरेव शान्तिः सामा शान्तिरेधि।।3।।
(यजुर्वेदः 36/17)

भावार्थ : द्युलोक शांतिदायक हो, अन्तरिक्षलोक तथा पृथ्वीलोक शांतिदायक हों, जल एवं ओषधियाँ तथा वनस्पतियाँ शांति देने वाली हों, सभी देवता अथवा सृष्टि की दिव्य शक्तियाँ शांति देने वाली हों, ब्रह्म अर्थात् महान् परमेश्वर या उसका दिया हुआ ज्ञान वेद, शांतिदायक हो, सम्पूर्ण चराचर जगत् शांतिप्रद हों, सब जगह शांति ही शांति हो, ऐसी शांति मुझे प्राप्त हो और वह सदा बढ़ती ही रहे।

अभिप्राय यह है कि सृष्टि के कण-कण में शान्ति हो। सभी पदार्थ सभी के लिए सुख-शांतिदायक हों। समस्त पर्यावरण ही हमारे लिए सुखद एवं शांतिप्रद हो। सुख-शांति की यह धारा कभी कम न हो, सदा बढ़ती ही रहे।। 3।।

प्रथमः पाठः

सूक्तिसुधा

प्रस्तुत पाठ चाणक्य द्वारा रचित चाणक्य-नीति तथा नारायण पण्डित प्रणीत हितोपदेश से संकलित किया गया है। महर्षि चाणक्य द्वारा कहे गए मुक्तक पद्य जीवन को मूल्यवान् बनाने के लिए परम उपयोगी हैं। पद्य संख्या एक से पाँच में– किस स्थान पर निवास करना चाहिए, कौन मनुष्य का सच्चा मित्र है, गुणों की उपयोगिता, जल की महत्ता तथा श्रेष्ठ विद्यार्थी के वर्णन हैं। पद्य संख्या छह से दस हितकारी उपदेशों को सूचित करती है यथा मूर्ख व्यक्ति का प्रवीण होना, मनस्वी व्यक्ति का व्यवहार, पुरुष के छह दोषों का वर्णन तथा सांसारिक जीवनसुखों के वर्णन। जीवन को मधुर तथा उद्देश्यपूर्ण बनाने के लिए कतिपय मूल्यों की आवश्यकता होती है और ये नीतिपरक पद्य तथा हितकारी उपदेश जीवन को सुसंस्कृत एवं सार्थक बनाने में उपयोगी तथा सहायक सिद्ध होंगे।

यस्मिन् देशे न सम्मानो न वृत्तिर्न च बान्धवाः।
न च विद्यागमः कश्चिद् वासं तत्र न कारयेत्।।1।।
आतुरे व्यसने प्राप्ते दुर्भिक्षे शत्रुसंकटे।
राजद्वारे श्मशाने च यस्तिष्ठति स बान्धवः।।2।।
कोऽतिभारः समर्थानां किं दूरं व्यवसायिनाम्।
को विदेशः सविद्यानां कोऽप्रियः प्रियवादिनाम्।।3।।

अजीर्णे भेषजं वारि जीर्णे वारि बलप्रदम्।
भोजने चामृतं वारि भोजनान्ते विषप्रदम्।।4।।
सुखार्थी चेत् त्यजेद् विद्यां विद्यार्थी चेत् त्यजेत् सुखम्।
सुखार्थिनः कुतो विद्या कुतो विद्यार्थिनः सुखम्।।5।।
काचः काञ्चनसंसर्गाद् धत्ते मारकतीं द्युतिम्।
तथा सत्सन्निधानेन मूर्खो याति प्रवीणताम्।।6।।
कुसुमस्तबकस्येव द्वयी वृत्तिर्मनस्विनः।
सर्वेषां मूर्ध्नि वा तिष्ठेद् विशीर्येत वनेऽथवा।।7।।
धनानि जीवितार्थं च परार्थे प्राज्ञ उत्सृजेत्।
सन्निमित्तं वरं त्यागो विनाशे नियते सति।।8।।
षड्दोषाः पुरुषेणेह हातव्या भूतिमिच्छता।
निद्रा तन्द्रा भयं क्रोध आलस्यं दीर्घसूत्रता।।9।।
अर्थागमो नित्यमरोगिता च प्रिया च भार्या प्रियवादिनी च।
वश्यश्च पुत्रोऽर्थकरी च विद्या षड्जीवलोकस्य सुखानि राजन्।।10।।

शब्दार्थाः टिप्पण्यश्च

विद्यागमः	—	विद्यायाः आगमः, षष्ठी तत्पुरुष समास, विद्या की प्राप्ति।
वृत्तिः	—	वृत् + क्तिन् , आजीविका
शत्रुसंकटे	—	शत्रोः संकटः, तस्मिन्, पंचमी तत्पुरुष, शत्रु से संकट होने पर।
व्यवसायिनाम्	—	उद्यमशीलों के लिए।
भेषजम्	—	औषधि।
भोजनान्ते	—	भोजनस्य अन्ते, षष्ठी तत्पुरुष।
सुखार्थी	—	सुख चाहने वाला।
धत्ते	—	धारण करता है।

सत्सन्निधानेन	—	सतां सन्निधानम्, तेन, षष्ठी तत्पुरुष, सज्जनों की संगति से।
कुसुमस्तबकः	—	कुसुमानां स्तबकः, षष्ठी तत्पुरुष, फूलों का गुच्छा।
विशीर्येत	—	नष्ट होवे।
उत्सृजेत्	—	त्याग दे।
सन्निमित्तं	—	श्रेष्ठ लक्ष्य के लिए।
दीर्घसूत्रता	—	कार्य के विषय में अधिक समय तक सोचते रहना, समय पर कार्य न करना।
अर्थागमः	—	अर्थस्य आगमः, षष्ठी तत्पुरुष, धन की प्राप्ति।
अर्थकरी	—	धन उत्पन्न करने वाली।
प्रियवादिनी	—	प्रिय बोलने वाली।
अरोगिता	—	किसी प्रकार के रोग का न होना (नीरोग होना)!

अभ्यासः

1. **संस्कृतेन उत्तरं देयम्**

   क) अयं पाठः काभ्यां ग्रंथाभ्यां संकलितः?

   ख) कुत्र वासः न कर्त्तव्यः?

   ग) वारि कदा भेषजं भवति?

   घ) विद्यार्थी किम् त्यजेत्?

   ङ.) प्राज्ञः परार्थे किम् किम् उत्सृजेत्?

   च) मूर्खः कथम् प्रवीणताम् याति?

   छ) पुरुषेण के षड्दोषाः हातव्याः?

2 **रिक्तस्थानपूर्तिः क्रियताम्**

   क) यः .... तिष्ठति सः बान्धवः।

   ख) जीवलोकस्य .... षट् सुखानि भवन्ति।

   ग) मनस्विनः .... इव द्वयी वृत्तिः भवति।

3. अधोलिखितयोः पद्यांशयोः भावार्थम् लिखत

क) कोऽप्रियः प्रियवादिनाम्।

ख) सन्निमित्तं वरं त्यागो विनाशे नियते सति।

4. क भागस्थपदैः सह ख भागस्यार्थानां मेलनं क्रियताम्

क	ख
विद्यागमः	विदुषाम्
व्यसने	शोभाम्
सविद्यानाम्	विद्याप्राप्तिः
द्युतिम्	पुष्पगुच्छस्य
कुसुमस्तबकस्य	विपत्तौ
मूर्ध्नि	कल्याणम्
भूतिम्	शिरसि

5. उदाहरणानुसारं विग्रहपदानि आधृत्य समस्तपदानि रचयत

यथा – विद्यायाः आगमः = विद्यागमः

विग्रहपदानि		समस्तपदानि
राज्ञः द्वारे	=	....
भोजनस्य अन्ते	=	....
काञ्चनस्य संसर्गात्	=	....
अर्थस्य आगमः	=	....

द्वितीयः पाठः

रामकृत-कुशलप्रश्नः

प्रस्तुत अंश वाल्मीकिरामायण के अयोध्याकांड के सौवें सर्ग से संकलित हैं। भगवान् श्रीराम चित्रकूट में वनवास कर रहे हैं। भ्रातृविरह से पीडित भरत श्रीराम से मिलने आए हैं। श्रीराम भरत से मिलने के बाद उनसे कुशल-प्रश्न करते हैं। इस प्रकरण में भरत राम से राज्यव्यवस्था संचालन संबंधी ऐसे अनेक प्रश्न करते हैं जिनसे राजनीतिविज्ञान पर महत्त्वपूर्ण प्रकाश पड़ता है।

श्रीराम ने भरत से प्रश्न किया है कि क्या उन्होंने मंत्रियों की नियुक्ति शास्त्रोक्त *अपेक्षाओं के अनुरूप की है? क्या मंत्रणा शास्त्रविधि से करते हैं? क्या उनका वेतन* भुगतान समय से किया जाता है? यह पाठ्यांश राज्यव्यवस्था की दृष्टि से अत्यंत महत्त्वपूर्ण है। इन्हीं बिंदुओं पर प्रस्तुत पाठ्यांश में विशद विवेचन किया गया है।

जटिलं चीरवसनं प्राञ्जलिं पतितं भुवि।
ददर्श रामो दुर्दर्शं युगान्ते भास्करं यथा।।1।।
कथञ्चिदभिविज्ञाय विवर्णवदनं कृशम्।
भ्रातरं भरतं रामः परिजग्राह पाणिना ।।2।।
आघ्राय रामस्तं मूर्ध्नि परिष्वज्य च राघवम्।
अङ्के भरतमारोप्य पर्यपृच्छत सादरम् ।।3।।
कच्चिदात्मसमाः शूराः श्रुतवन्तो जितेन्द्रियाः।
कुलीनाश्चेङ्गितज्ञाश्च कृतास्ते तात मन्त्रिणः।।4।।
मन्त्रो विजयमूलं हि राज्ञां भवति राघव।

सुसंवृतो मन्त्रिधुरैरमात्यैः शास्त्रकोविदैः ।।5।।
कच्चिन्निद्रावशं नैषि कच्चित्कालेऽवबुध्यसे।
कच्चिच्चापररात्रेषु चिन्तयस्यर्थनैपुणम्।।6।।
कच्चिन्मन्त्रयसे नैकः कच्चिन्न बहुभिः सह।
कच्चित्ते मन्त्रितो मन्त्रो राष्ट्रं न परिधावति।।7।।
कच्चिदर्थं विनिश्चित्य लघुमूलं महोदयम्।
क्षिप्रमारभसे कर्म न दीर्घयसि राघव।।8।।
कच्चित्सहस्रान्मूर्खाणामेकमिच्छसि पण्डितम्।
पण्डितो ह्यर्थकृच्छ्रेषु कुर्यान्निःश्रेयसं महत्।।9।।
एकोऽप्यमात्यो मेधावी शूरो दक्षो विचक्षणः।
राजानं राजपुत्रं वा प्रापयेन्महतीं श्रियम्।।10।।
कच्चिन्मुख्या महत्स्वेव मध्यमेषु च मध्यमाः।
जघन्याश्च जघन्येषु भृत्यास्ते तात योजिताः।।11।।
अमात्यानुपधातीतान्पितृपैतामहांछुचीन्।
श्रेष्ठांछ्रेष्ठेषु कच्चित्त्वं नियोजयसि कर्मसु।।12।।
कच्चिद्धृष्टश्च शूरश्च धृतिमान्मतिमांछुचिः।
कुलीनश्चानुरक्तश्च दक्षः सेनापतिः कृतः।।13।।
कच्चिद्बलस्य भक्तं च वेतनं च यथोचितम्।
सम्प्राप्तकालं दातव्यं ददासि न विलम्बसे।।14।।
कालातिक्रमणाच्चैव भक्तवेतनयोर्भृताः।
भर्तुरप्यतिकुप्यन्ति सोऽनर्थः सुमहान्स्मृतः।।15।।

शब्दार्थाः टिप्पण्यश्च

जटिलम् — जटाधारी को।
ददर्श — देखा।

दुर्दर्शम्	—	दुःखपूर्वक देखा जाने योग्य।
विवर्णवदनम्	—	खिन्न मुख वाला।
परिजग्राह	—	ग्रहण किया।
परिष्वज्य	—	आलिंगन करके।
आघ्राय	—	सूँघकर।
मन्त्रः	—	मंत्रणा।
शास्त्रकोविदैः	—	शास्त्रस्य कोविदैः, षष्ठी-तत्पुरुष, शास्त्र के ज्ञाताओं के द्वारा।
अवबुध्यसे	—	जागते हो।
मन्त्रयसे	—	मंत्रणा करते हो।
दीर्घयसि	—	विलम्ब करते हो।
अर्थकृच्छ्रेषु	—	अर्थस्य कृच्छ्रेषु, षष्ठी-तत्पुरुष, धन की कठिनाइयों में।
निःश्रेयसम्	—	कल्याण।
अमात्यः	—	मंत्री।
विचक्षणः	—	निपुण।
जघन्यः	—	निंदनीय।
एषि	—	प्राप्त होते हो।
नियोजयसि	—	नियुक्त करते हो।
दक्षः	—	चतुर, निपुण।
भक्तवेतनयोः	—	भोजन और वेतन से।
उपधातीतान्	—	राजाओं के द्वारा किये गये मंत्रियों के परीक्षण से शुद्ध होकर निकले हुए।
धृष्टः	—	किसी के दबाव में न आने वाला।

सन्धिविच्छेदः

पर्यपृच्छत	=	परि + अपृच्छत (आर्षप्रयोग)
नैषि	=	न + एषि
नैकः	=	न + एकः
ह्यर्थकृच्छ्रेषु	=	हि + अर्थकृच्छ्रेषु
कुलीनाश्च	=	कुलीनाः + च
भृत्याश्च	=	भृत्याः + च
कालातिक्रमणाच्चैव	=	काल + अतिक्रमणात् + च +एव
भर्तुरप्यतिकुप्यन्ति	=	भर्तुः + अपि + अतिकुप्यन्ति
सोऽनर्थः	=	सः + अनर्थः

अभ्यासः

1. **संस्कृतेन उत्तरं देयम्**

    क) अयम् पाठः कस्माद् ग्रन्थात् सङ्कलितः?

    ख) जटिलः चीरवसनः भुवि पतितः कः आसीत्?

    ग) रामःकम् पाणिना परिजग्राह?

    घ) भरतम् कः अपृच्छत्?

    ङ) राज्ञां विजयमूलं किम् भवति?

    च) राज्ञः कृते कीदृशः अमात्यः क्षेमकरः भवेत्?

    छ) सेनापतिः कीदृग् गुणयुक्तः भवेत्?

    ज) बलेभ्यः यथाकालम् किं दातव्यम्?

2. **रिक्तस्थानपूर्तिः क्रियताम्**

    क) रामः ददर्श दुर्दर्शं युगान्ते................... यथा।

    ख) अङ्के .... आरोप्य रामः सादरं पर्यपृच्छत।

    ग) कच्चित् काले ....?

घ) पण्डितः हि अर्थकृच्छ्रेषु .... कुर्यात्।

ङ) श्रेष्ठाच्छ्रेष्ठेषु कच्चित् एवं .... नियोजयसि।

3. **सप्रसङ्गं व्याख्यायेताम्**

क) मन्त्रो विजयमूलं हि राज्ञां भवति राघव।

ख) कच्चित्ते मन्त्रितो मन्त्रो राष्ट्रं न परिधावति।

4. **प्रथमनवमश्लोकयोः स्वमातृभाषया अनुवादः क्रियताम्**

5. **अधोलिखितपदानां उचितमर्थं कोष्ठकाद् चित्वा लिखत**

क) दुर्दर्शम् =

ख) परिष्वज्य =

ग) आघ्राय =

घ) मूर्ध्नि =

ङ) निःश्रेयसम् =

च) विचक्षणः =

छ) बलस्य =

(आलिंगन करके), (सूँघकर), (कठिनाई से देखने योग्य), (निपुण), (सेना का), (शिर में), (कल्याण को)

6. **विपरीतार्थमेलनं क्रियताम्**

एकः	शनैः
क्षिप्रम्	मूर्खः
पण्डितः	लघु
महत्	बहु

7. **सन्धिविच्छेदः क्रियताम्**

यथा – कुलीनश्च = कुलीनः + च

भृत्याश्च =

धृष्टश्च =

अनुरक्तश्च =

शूरश्च =

तृतीयः पाठः

दैवपुरुषकारबलाबलम्

प्रस्तुत पाठ महर्षि वेदव्यास द्वारा रचित महाभारत नामक महाकाव्य के अनुशासनपर्व से लिया गया है। इस पर्व के छठे अध्याय में युधिष्ठिर पितामह भीष्म से यह प्रश्न पूछते हैं कि भाग्य और कर्म में से कौन श्रेष्ठ है। उनके वक्तव्य का सार यह है कि कर्म के बिना भाग्य भी फलित नहीं होता। शुभ कर्म से सुख तथा पापकर्म से दुख की प्राप्ति होती है। कर्म से ही मनुष्य देवत्व को प्राप्त करता है। इस पाठ में युधिष्ठिर तथा भीष्म के इसी संवाद को प्रस्तुत किया गया है।

युधिष्ठिर उवाच –

पितामह महाप्राज्ञ सर्वशास्त्रविशारद।

दैवे पुरुषकारे च किंस्विच्छ्रेष्ठतरं भवेत्।।1।।

भीष्म उवाच –

अत्राप्युदाहरन्तीममितिहासं पुरातनम्।

वसिष्ठस्य च संवादं ब्रह्मणश्च युधिष्ठिर।।2।।

दैवमानुषयोः किंस्वित्कर्मणोः श्रेष्ठमित्युत।

पुरा वसिष्ठो भगवान्पितामहमपृच्छत।।3।।

ततः पद्मोद्भवो राजन्देवदेवः पितामहः।

उवाच मधुरं वाक्यमर्थवद्धेतुभूषितम्।।4।।

नाबीजं जायते किञ्चिन्न बीजेन विना फलम्।

बीजाद्बीजं प्रभवति बीजादेव फलं स्मृतम्।।5।।
यादृशं वपते बीजं क्षेत्रमासाद्य कर्षकः।
सुकृते दुष्कृते वापि तादृशं लभते फलम्।।6।।
शुभेन कर्मणा सौख्यं दुःखं पापेन कर्मणा।
कृतं सर्वत्र लभते नाकृतं भुज्यते क्वचित्।।7।।
ज्योतींषि त्रिदशा नागा यक्षाश्चन्द्रार्कमारुताः।
सर्वे पुरुषकारेण मानुष्याद्देवतां गताः।।8।।
अर्थो वा मित्रवर्गो वा ऐश्वर्यं वा कुलान्वितम्।
श्रीश्चापि दुर्लभा भोक्तुं तथैवाकृतकर्मभिः।।9।।
नादातारं भजन्त्यर्था न क्लीबं नापि निष्क्रियम्।
नाकर्मशीलं नाशूरं तथा नैवातपस्विनम्।।10।।
एवं चेत्कर्मफलं न स्यात्सर्वमेवाफलं भवेत्।
लोको दैवं समालम्ब्य उदासीनो भवेन्नतु।।11।।
आत्मैव ह्यात्मनो बन्धुरात्मैव रिपुरात्मनः।
आत्मैव चात्मनः साक्षी कृतस्याप्यकृतस्य च।।12।।

शब्दार्थाः टिप्पण्यश्च

सर्वशास्त्रविशारदः — सभी शास्त्रों में कुशल।
उवाच — बोले।
प्रभवति — पैदा होता है।
वपते — बोता है।
क्षेत्रम् — खेत।
सुकृते — अच्छे कर्म में।
दुष्कृते — बुरे कर्म में।
सस्यम् — अन्न।

समृध्यते	–	वृद्धि को प्राप्त करता है।
त्रिदशाः	–	देवता।
क्लीबम्	–	नपुंसक।
तप्यते	–	तप करता है।
खम्	–	आकाश।
दैवम्	–	भाग्य।
रिपुः	–	शत्रु।
साक्षी	–	गवाह।

सन्धिविच्छेदः

किंस्विच्छ्रेष्ठतरम्	=	किंस्वित् + श्रेष्ठतरम्
आत्राप्युदाहरन्तीममितिहासम्	=	अत्र + अपि + उदाहरन्ति + इमम् + इतिहासम्
पद्मोद्भवः	=	पद्म + उद्भवः
श्रीश्चापि	=	श्रीः + च + अपि
भवेन्न	=	भवेत् + न
ह्यात्मनः	=	हि + आत्मनः
बन्धुरात्मैव	=	बन्धुः + आत्मा + एव
कृतस्याप्यकृतस्य	=	कृतस्य + अपि + अकृतस्य

अभ्यासः

1. **अधोलिखितानां प्रश्नानाम् उत्तराणि संस्कृतभाषया देयानि**
   - क) पाठोऽयं कस्माद् ग्रन्थाद् उद्धृतः ?
   - ख) महाभारतम् कः रचितवान् ?

ग) युधिष्ठिरः पितामहं किम् अपृच्छत्?

घ) फलम् कस्माद् जायते?

ङ) जनः सर्वत्र किं लभते?

च) सर्वे केन मानुष्याद् देवतां गताः?

छ) लोकः कम् समालम्ब्य उदासीनो न भवेत्?

ज) कृतस्य अकृतस्य च कः साक्षी?

झ) अर्थाः कं कं न भजन्ति?

2. समक्षकोष्ठकाद् उचितपदम् आदाय रिक्तस्थानपूर्तिः क्रियताम्

क) .... अर्थवद्धेतुभूषितम् मधुरं वाक्यम् उवाच।

(युधिष्ठिरः/पितामहः)

ख) .... किंचित् न जायते। (बीजम्/ अबीजम्)

ग) यादृशं वपते बीजम् .... लभते फलम्। (अयम् /तादृशं)

घ) सर्वे पुरुषकारेण .... देवतां गताः। (मानुष्यात्/मृत्युलोकात्)

ङ) लोकः .... समालम्ब्य उदासीनः न भवेत्। (धनम्/दैवम्)

3. अधोलिखितानाम् आशयः स्पष्टीक्रियताम्

क) नाबीजं जायते किञ्चिन्न बीजेन विना फलम्।

ख) कृतं सर्वत्र लभते नाकृतं भुज्यते क्वचित्।

ग) सर्वे पुरुषकारेण मानुष्याद्देवतां गताः।

4. अधोलिखितौ पद्यांशौ व्याख्यायेताम्

क) यादृशं वपते बीजं तादृशं लभते फलम्।

ख) आत्मैव ह्यात्मनो बन्धुरात्मैव रिपुरात्मनः।

5. सन्धिविच्छेदः क्रियताम्

यथा – नाबीजम् = न + अबीजम्

नाशूरम् = ...

नातपस्विनम् = ...

वापि = ...
नापि = ...
नाकृतम् = ...
कुलान्वितम् = ...

6. **अधोलिखितेषु पदेषु धातुं/ प्रत्ययं च पृथक्कृत्य लिखत**

यथा – भूषितम् भूष् क्त

पदम्	**धातुः**	**प्रत्ययः**
स्मृतम्	....	....
कृतम्	....	....
गताः	....	....
उप्तम्	....	....

7. **अधोलिखितपदानां विपरीतार्थकं पदं समक्षं प्रदत्तकोष्ठकात् चित्वा लिखत**

(पुरुषकारे, अकृतम्, दुःखम्, रिपुः, देवताः, पापेन, दुष्कृते)

यथा – दैवे पुरुषकारे

पदम्	**विपरीतार्थकपदम्**
सुकृते	....
शुभेन	....
सौख्यम्	....
कृतम्	....
दैत्याः	....
बन्धुः	....

चतुर्थः पाठः

आश्रमजीवनम्

यह पाठ महाकवि भासकृत स्वप्नवासवदत्तम् नाटक के प्रथमांक से संकलित है। राजकुमारी पद्मावती अपनी आश्रमवासिनी माता से मिलने के लिए आश्रम में जाती है। वहाँ राजकुमारी के अंगरक्षक उसके मार्ग से लोगों को हटा रहे हैं। वृद्ध कंचुकी उन्हें समझाते हुए कहता है कि आश्रम के निवासी नगर के परिभवों से मुक्त होने के लिए यहाँ आकर रहते हैं। सांसारिक वासनाओं से मुक्त होने के कारण वे सर्वथा समादरणीय हैं। वहीं यौगन्धरायण के साथ वासवदत्ता भी पहुँची हुई है जो पद्मावती के व्यक्तित्व से प्रभावित है। यही प्रसंग इस पाठ में वर्णित है।

यौगन्धरायणः : (कर्णं दत्वा), कथमिहाप्युत्सार्यते? कुतः -

धीरस्याश्रमसंश्रितस्य वसतस्तुष्टस्य वन्यैः फलै-
र्मानार्हस्य जनस्य वल्कलवतस्त्रासः समुत्पाद्यते।
उत्सिक्तो विनयादपेतपुरुषो भाग्यैश्चलैर्विस्मितः
कोऽयं भो? निभृतं तपोवनमिदं ग्रामीकरोत्याज्ञया।।

वासवदत्ता : आर्य ! क एष उत्सारयति?

यौगन्धरायणः : भवति ! यो धर्मादात्मानमुत्सारयति।

वासवदत्ता : आर्य ! न ह्येवं वक्तुकामा, अहमपि नामोत्सारयितव्या भवामीति।

यौगन्धरायणः : भवति ! एवमनिर्ज्ञातानि दैवतान्यवधूयन्ते।

वासवदत्ता : आर्य ! तथा परिश्रमः परिखेदं नोत्पादयति, यथाह्ययं परिभवः।

यौगन्धरायणः	:	भुक्तोज्झित एष विषयोऽत्रभवत्या। नात्र चिन्ता कार्या। कुतः,

पूर्वं त्वयाप्यभिमतं गतमेवमासी-
च्छ्लाध्यं गमिष्यसि पुनर्विजयेन भर्तुः।
कालक्रमेण जगतः परिवर्तमाना
चक्रारपङ्क्तिरिव गच्छति भाग्यपङ्क्तिः।।

भटौ	:	उत्सरतार्याः, उत्सरत।
		(ततः प्रविशति काञ्चुकीयः)
काञ्चुकीयः	:	सम्भषक ! न खलु न खलूत्सारणा कार्या।
उभौ	:	आर्य ! तथा।
		(निष्क्रान्तौ)
यौगन्धरायणः	:	हन्त ! सविज्ञानमस्य दर्शनम्। वत्से ! उपसर्पावस्तावदेनम्।
वासवदत्ता	:	आर्य ! तथा।
यौगन्धरायणः	:	(उपसृत्य) भोः ! किङ्कृतेयमुत्सारणा।
काञ्चुकीयः	:	भोस्तपस्विन् !
यौगन्धरायणः	:	(आत्मगतम्) तपस्विन्निति गुणवान् खल्वयमालापः। अपरिचयात्तु न श्लिष्यते मे मनसि।
काञ्चुकीयः	:	भोः ! श्रूयताम्। एषा खलु गुरुभिरभिहितनामधेयस्य अस्माकं महाराजदर्शकस्य भगिनी पद्मावती नाम। सैषा नो महाराजमातरं महादेवीमाश्रमस्थामभिगम्यानुज्ञाता तत्रभवत्या राजगृहमेव यास्यति। तदद्यास्मिन् आश्रमपदे वासोऽभिप्रेतोऽस्याः।
यौगन्धरायणः	:	(स्वगतम्)एवम् ! एषा सा मगधराजपुत्री पद्मावती नाम, या पुष्पकभद्रादिभिरादेशिकैरादिष्टा स्वामिनो देवी भविष्यतीति। ततः-

प्रद्वेषो बहुमानो वा संङ्कल्पादुपजायते।
भर्तृदाराभिलाषित्वादस्यां मे महती स्वता।।

वासवदत्ता	:	(स्वगतम्) राजदारिकेति श्रुत्वा भगिनिकास्नेहोऽपि मेऽत्र संपद्यते।
		(ततः प्रविशति पद्मावती सपरिवारा चेटी च)
चेटी	:	एत्वेतु, भर्तृदारिका, इदमाश्रमपदम्, प्रविशतु। (ततः प्रविशत्युपविष्टा तापसी)
तापसी	:	स्वागतं राजदारिकायाः
वासवदत्ता	:	(स्वगतम्) इयं सा राजदारिका। अभिजनानुरूपं खल्वस्या रूपम्।
पद्मावती	:	आर्ये ! वन्दे।
तापसी	:	चिरञ्जीव। प्रविश जाते। प्रविश। तपोवनानि नामाऽतिथिजनस्य स्वगेहम्।
पद्मावती	:	आर्ये ! भवतु, भवतु। आर्ये ! विश्वस्तास्मि। अनेन बहुमानवचनेनानुगृहीतास्मि।
वासवदत्ता	:	(स्वगतम्) नहि रूपमेव, वागपि खल्वस्या मधुरा।

शब्दार्थाः टिप्पण्यश्च

उत्सार्यते	—	हटाया जा रहा है।
वन्यैः फलैः	—	वन में पैदा होने वाले फलों से।
मानार्हस्य जनस्य	—	सम्मान के योग्य व्यक्ति का।
त्रासः	—	भय।
उत्सिक्तः	—	अहंकार से प्रमत्त।
निभृतम्	—	शांत।
ग्रामीकरोति	—	ग्राम बना रहा है।
अनिर्ज्ञातानि	—	अनजाने।
अवधूयन्ते	—	तिरस्कृत होते हैं।

परिभवः – तिरस्कार।
प्रद्वेषः – वैर।
संवृत्ता – हो गयी है।
उपसर्पावः – हम दोनों पास चलते हैं

सन्धिविच्छेदः

ह्येवम् = हि + एवम्
नामोत्सारयितव्या = नाम + उत्सारयितव्या
भुक्तोज्झितः = भुक्त + उज्झितः
खल्वस्याः = खलु + अस्याः
सैषा = सा + एषा
तदद्य = तत् + अद्य
आसीच्छ्लाघ्यम् = आसीत् + श्लाघ्यम्
एत्वेतु = एतु + एतु

अभ्यासः

1. **अधोलिखितानां प्रश्नानाम् उत्तराणि संस्कृतभाषया देयानि**
   क) अयं पाठः कस्मात् पुस्तकात् संगृहीतः कश्च तस्य प्रणेता?
   ख) "निभृतं तपोवनमिदं ग्रामीकरोत्याज्ञया" इति कः कथयति?
   ग) "तथा परिश्रमः परिखेदं नोत्पादयति यथाह्ययं परिभवः" इति कस्याः वचनम्?
   घ) भाग्यपङ्क्तिः किमिव गच्छति?
   ङ) वासवदत्ता का अस्ति?
   च) पद्मावती का अस्ति?
   छ) पद्मावती केषु धर्मपीडाम् न इच्छति?
   ज) वासवदत्ता पद्मावतीं दृष्ट्वा किं कथयति?

2. रिक्तस्थानपूर्तिः क्रियताम्

क) अनिर्ज्ञातानि .... अवधूयन्ते।

ख) .... अस्य दर्शनम्।

ग) एषा सा .... पद्मावती नाम।

घ) नहि रूपमेव .... अस्याः मधुरा।

3. सप्रसङ्गं व्याख्यायन्ताम्

क) चक्रारपङ्क्तिरिव गच्छति भाग्यपङ्क्तिः।

ख) प्रद्वेषो बहुमानो वा सङ्कल्पादुपजायते।

ग) तपोवनानि नाम अतिथिजनस्य गेहम्।

4. धीरस्याश्रमसंश्रितस्य, पूर्वं त्वयाप्यभिमतं इति श्लोकद्वयस्य स्वमातृभाषया अनुवादः कार्यः

5. सन्धिविच्छेदः क्रियताम्

त्वयाप्यभिमतम् =

चोत्पादयन्ति =

वागपि =

तदपि =

6. अधोलिखितपदानाम् समानार्थकं पदं कोष्ठकात् चिनुत

क) परिभवः – (विभवः/ तिरस्कारः)

ख) निभृतम् – (शान्तम् / विभृतम्)

ग) उत्सारणा – (उत्प्रेरणा/ अपसारणा)

घ) आलापः – (विलापः / संलापः)

ङ) कुसुमानि – (सुमनानि / कुत्सितानि)

पञ्चमः पाठः

पञ्चमहाभूतानि

प्रस्तुत अंश तर्कसंग्रह से संकलित हैं। तर्कसंग्रह के प्रणेता श्री अन्नंभट्ट हैं। संकलित अंश में पाँच महाभूतों का परिचय दिया गया है। पाँचमहाभूत हैं - पृथ्वी, जल, तेज, वायु तथा आकाश। इन पाँचों महाभूतों का वैज्ञानिक विश्लेषण उद्धृत अंश में किया गया है।

इनमें प्रथमतः चार महाभूतों पृथ्वी, जल, तेज एवं वायु के लक्षण बताने के बाद प्रत्येक के पाँच भेद बताए गए हैं। आकाश का लक्षण बताकर उसको एक ही प्रकार का माना है।

ये चार महाभूत शरीर, इन्द्रिय और विषय में कहाँ कहाँ रहते हैं, इसका तात्त्विक विवेचन प्रस्तुत पाठ्यांश में किया गया है।

ये महाभूत शरीर रूप से अपने मूल स्थान में रहते हैं और इन्द्रिय रूप से प्राणियों की उन-उन इन्द्रियों में रहते हैं तथा विषय रूप से संबद्ध पदार्थों में रहते हैं।

पृथिवी, अप्, तेजः, वायुः, आकाशश्चेति पञ्चमहाभूतानि। तत्र गन्धवती पृथिवी। सा द्विविधा - नित्याऽनित्या च। नित्या परमाणुरूपा। अनित्या कार्यरूपा। पुनस्त्रिविधा। शरीरेन्द्रियविषयभेदात्। शरीरमस्मदादीनाम्। इन्द्रियं गन्धग्राहकं घ्राणं नासाग्रवर्ति। विषयो मृत्पाषाणादिः।

शीतस्पर्शवत्य आपः। ताः द्विविधाः। नित्याऽनित्याश्च। नित्याः परमाणुरूपाः। अनित्याः कार्यरूपाः। पुनस्त्रिविधाः - शरीरेन्द्रियविषयभेदात्।

शरीरं वरुणलोके। इन्द्रियं रसग्राहकं रसनं जिह्वाग्रवर्ति। विषयः सरित्समुद्रादिः।

उष्णस्पर्शवत्तेजः। तच्च द्विविधम्। नित्यमनित्यं च। नित्यं परमाणुरूपम्। अनित्यं कार्यरूपम्। पुनस्त्रिविधम्। शरीरेन्द्रियविषयभेदात्। शरीरमादित्यलोके प्रसिद्धम्। इन्द्रियं रूपग्राहकं चक्षुः कृष्णताराग्रवर्त्ति। विषयश्चतुर्विधो भौमदिव्योदर्याकरजभेदात्। भौमं वह्न्यादिकम्। अबिन्धनं दिव्यं विद्युदादि। भुक्तस्य परिणामहेतुरुदर्यम्। आकरजं सुवर्णादि।

रूपरहितः स्पर्शवान् वायुः। स द्विविधः - नित्योऽनित्यश्च। नित्यः परमाणुरूपः। अनित्यः कार्यरूपः। पुनस्त्रिविधः। शरीरेन्द्रियविषयभेदात्। शरीरं वायुलोके। इन्द्रियं स्पर्शग्राहकं त्वक् सर्वशरीरवर्ति। विषयो वृक्षादिकम्पनहेतुः। शरीरान्तःसंचारी वायुः प्राणः। स चैकोऽप्युपाधिभेदात् प्राणापानादिसंज्ञां लभते।

शब्दगुणकमाकाशम्। तच्चैकं विभु नित्यं च।

शब्दार्थाः टिप्पण्यश्च

अप्	—	जल।
गन्धवती	—	गन्ध से युक्त, गन्ध + मतुप्, स्त्री।
द्विविधा	—	दो प्रकार की।
नित्या	—	त्रैकालिकसत्तायुक्ता, तीनों कालों में जो रहे।
अनित्या	—	न नित्या इति, जो किसी एक काल में न रहे।
अस्मदादीनाम्	—	हम जैसों का।
मृत्पाषाणादि	—	मृदश्च पाषाणाश्च इति, मिट्टी और पत्थर।
शीतस्पर्शवत्यः	—	शीतस्पर्शः वर्तते यासाम्, शीतल स्पर्श से युक्त।

सरित्समुद्रादिः	—	सरितश्च समुद्रश्चेति, नदियाँ व समुद्र आदि।
आदित्यलोके	—	सूर्यलोके, सूर्य लोक में।
भौमदिव्योदर्याकरजभेदात्	—	भौम - भूमि संबंधी अग्नि। दिव्य - देवसंबंधी या अलौकिक यथा आकाश में चमकने वाली तड़ित् (विद्युत्) उदर्य- उदर संबंधी अग्नि (तेज) जो खाए भोजन को पचाती है। आकरज - जो तेज खनन से निकाला गया हो यथा स्वर्ण संबंधी।
उपाधिभेदात्	—	उपाधि के भेद से।
प्राणापानादि	—	पाँच प्रकार की वायु जो शरीर में रहती है - प्राण, अपान, व्यान, समान व उदान।
विभु	—	सर्वव्यापक।

अभ्यासः

1. **संस्कृतभाषया उत्तराणि प्रदेयानि**
   - क) पञ्चमहाभूतानि कानि?
   - ख) तत्र किंलक्षणा पृथिवी?
   - ग) अपां किं लक्षणम्?
   - घ) तेजसः किं स्वरूपम्?
   - ङ) रूपरहितः स्पर्शवान् इति कस्य लक्षणम्?
   - च) शब्दगुणकं किं भवति?
2. **रिक्तस्थानपूर्तिः करणीया**
   - क) इन्द्रियं गन्धग्राहकं .... नासाग्रवर्ति।
   - ख) इन्द्रियं रसग्राहकं .... जिह्वाग्रवर्ति।
   - ग) .... चक्षुः कृष्णताराग्रवर्ति।
   - घ) शरीरान्तःसंचारी .... प्राणः।

3. अधोलिखितानां व्याख्या कार्या

क) तत्र गन्धवती पृथिवी।

ख) विषयश्चतुर्विधो भौमदिव्योदर्याकरजभेदात्।

ग) इन्द्रियं स्पर्शग्राहकं त्वक् सर्वशरीरवर्ति।

घ) शब्दगुणकमाकाशम्।

4. पञ्चमहाभूतानां स्वरूपं स्वभाषया स्पष्टीकुरुत

5. अधोलिखितानि वाक्यानि केन सम्बद्धानि इति यथानिर्दिष्टं लिखत

शरीरं वरुणलोके

शरीरमस्मदादीनाम्

शरीरं वायुलोके

शरीमादित्यलोके

विषयो मृत्पाषाणादिः

विषयः सरित्समुद्रादिः

विषयो वृक्षादिकम्पनहेतुः

अबिन्धनं दिव्यं विद्युदादि।

पृथिवी

वायुः

तेजः

आपः

6. अधोलिखितपदानामर्थमेलनं क्रियताम्

घ्राणम्, आपः, मृत्, सरित्, चक्षुः, वह्निः आकरजम्, त्वक्, विभुः

अर्थाः	पदानि	अर्थाः	पदानि
जल		स्पर्शेन्द्रिय	
नासिका		आग	
नदी		व्यापक	
नेत्र		खानों से उत्पन्न	
		मिट्टी	

षष्ठ: पाठः

ब्रह्माण्डवर्णनम्

प्रस्तुत पाठ सूर्यसिद्धान्त के भूगोलाध्याय से लिया गया है। मयासुर (पौराणिक आख्यानानुसार यह लंका के अधिपति रावण का श्वसुर था) के पूछने पर सूर्यांश पुरुष ने सृष्टि की रहस्य-विद्या का प्रवचन किया जो कि ब्रह्माण्ड की संरचना (Structure of Universe) को स्पष्ट करती है। यह पाठ इसका भी परिचायक है कि सृष्टि के आदिकाल से ही मनुष्य रहस्यों के अन्वेषण के प्रति जिज्ञासु व जागरूक रहा है। मनुष्य की वैज्ञानिकी प्रवृत्ति निरंतर अपने आदि स्रोत को जानने के लिए उत्सुक तथा क्रमिक विकास के निर्धारण के प्रति प्रयत्नशील रही है। प्रस्तुत किए गए इस अंश में ब्रह्मा के मनस् से चंद्रमा की उत्पत्ति, तदनंतर पाँच तारा ग्रह - मंगल, बुध, बृहस्पति, शुक्र एवं शनि की स्थिति, ग्रह, नक्षत्र तथा तारों का क्रम, गोल के रूप उनकी आकृति, परिधि, व्योम, कक्षा व भ्रमण आदि का वर्णन है।

मयासुर आह-

भगवन् ! किम्प्रमाणा भूः किमाकारा किमाश्रया।
किंविभागा कथं चात्र सप्त पातालभूमयः।।1।।
अहोरात्रव्यवस्थां च विदधाति कथं रविः।
कथं पर्येति वसुधां भुवनानि विभावयन्।।2।।
भूमेरुपर्युपर्यूर्ध्वाः किमुत्सेधाः किमन्तराः।

ग्रहर्क्षकक्षा:किम्मात्राः स्थिताः केन क्रमेण ताः।।3।।

सूर्यांशपुरुषो मयासुरमाह –

प्रकृत्यन्तर्गतो देवो बहिरन्तश्च सर्वगः।
सङ्कर्षणोऽपः सृष्ट्वादौ तासु वीर्यमवासृजत्।।4।।
तदण्डमभवद् हैमं सर्वत्र तमसावृतम्।
तत्रानिरुद्धः प्रथमं व्यक्तिभूतः सनातनः।।5।।
हिरण्यगर्भो भगवानेष च्छन्दसि पठ्यते।
आदित्यो ह्यादिभूतत्वात् प्रसूत्या सूर्य उच्यते।।6।।
रथे विश्वमये चक्रं कृत्वा संवत्सरात्मकम्।
छन्दांस्यश्वास्तत्र युक्त्वा पर्यटत्येष सर्वदा।।7।।
अथ सृष्ट्यां मनश्चक्रे ब्रह्माहङ्कारमूर्तिभृत्।
मनसश्चन्द्रमा जज्ञे सूर्योऽक्ष्णोस्तेजसां निधिः।।8।।
मनसः खं ततो वायुरग्निरापो धरा क्रमात्।
गुणैकवृद्ध्या पञ्चेति महाभूतानि जज्ञिरे।।9।।
अग्नीषोमौ भानुचन्द्रौ ततस्त्वङ्गारकादयः।
तेजोभूखाम्बुवातेभ्यः क्रमशः पञ्च जज्ञिरे।।10।।
ग्रहनक्षत्रताराणां भूमेर्विश्वस्य वा विभुः।
देवासुरमनुष्याणां सिद्धानां च यथाक्रमम्।।11।।
ब्रह्माण्डमेतत् सुषिरं तत्रेदं भूर्भुवादिकम्।
कटाहद्वितयस्येव सम्पुटं गोलकाकृतिः।।12।।
ब्रह्माण्डमध्ये परिधिर्व्योमकक्षाऽभिधीयते।
तन्मध्ये भ्रमणं भानामधोऽधः क्रमशस्तथा।।13।।
मन्दामरेज्य-भूपुत्र-सूर्य-शुक्रेन्दुजेन्दवः।
परिभ्रमन्त्यधोऽधस्थाः सिद्धा विद्याधरा घनाः।।14।।

शब्दार्थाः टिप्पण्यश्च

ब्रह्माण्डम्	—	जड़ चेतनमय समस्त जगत्, जो ब्रह्म द्वारा स्थापित हिरण्यगर्भ से आविर्भूत हुआ है।
भूः	—	पृथिवी।
किम्प्रमाणा	—	किं प्रमाणं हेतुर्यस्याः सा। पृथ्वी की सत्ता का क्या कारण है?
किमाश्रया	—	क आश्रय आधारो यस्याः सा। यह भू किस आधार पर टिकी हुई है।
पातालभूमयः	—	पातालविभागरूपाः पुराणादिषूक्ताः सप्तलोकाः, पुराणों में कहे गए पाताल के सात विभाग- अतल, वितल, सुतल,रसातल, तलातल, महातल एवं पाताल।
अहोरात्रव्यवस्थाम्	—	अह्नः (दिनस्य) रात्रेश्च व्यवस्थाम्, दिन व रात की व्यवस्था अथवा क्रम को।
रविः	—	भ्रमणशीलो बिम्बरूपो भगवान् सूर्यः, भ्रमण करने वाले भगवान् सूर्य का बिम्बरूप जो दिन व रात का कारण है।
विदधाति	—	करोति, करता है।
पर्येति	—	परिभ्रमति, घूमता है।
भुवनानि	—	पृथ्वी लोक से ऊपर के सात लोक – भूः, भुवः, स्वः, महः, जनः, तपः और सत्य, इनकी संज्ञा भुवन है।
विभावयन्	—	स्वकरप्रकाशेन प्रकाशयन् – अपनी किरणों के प्रकाश द्वारा प्रकाश करता हुआ।

किमुत्सेधाः — कियानुत्सेध उच्चता यासां ताः, भूमेः सकाशात् प्रत्येकं कियदन्तरेण सन्तीति, कितनी ऊँचाई पर (भूमि से लेकर ये लोक कितनी - कितनी दूरी पर हैं।)

ग्रहर्क्षकक्षाः — ग्रहः, ऋक्षः (नक्षत्रम्) ग्रह + ऋक्षम् , ग्रहर्क्षाणां कक्षा, ग्रह व नक्षत्रों की कक्षाओं का क्रम, किस ग्रह की कक्षा के ऊपर किस दूसरे ग्रह की कक्षा है।

प्रकृत्यन्तर्गतः — प्रकृतिर्हि ब्राह्मी माया तदन्तर्गतः मायोपहितः सन्, प्रकृति ब्रह्म की माया है, उसके अन्तर्गत अथवा माया से युक्त हुआ।

सङ्कर्षणः — सङ्कर्षणो नाम वासुदेवांशः, वासुदेव के अंश का नाम।

अपः — जलानि, जल।

सृष्ट्वा — निर्माय, निर्माण करके।

वीर्यम् — शक्तिविशेषम्, विशेष शक्ति को।

अवासृजत् — निक्षिप्तवानिति, डाल दिया।

तदण्डम् — सङ्कर्षणोत्क्षिप्तवीर्यं जलसंयोगेन गोलकाकृतिपिण्डम्, संकर्षण से खींच कर डाले गए वीर्य व जल के संयोग से गोल की आकृति में उत्पन्न हुआ पिण्ड।

हैमम् — सौवर्णम्, सोने जैसे वर्ण वाला।

सनातनः — नित्यः , अनिरुद्धः नित्य बिना किसी अवरोध वाला।

व्यक्तिभूतः	—	अभिव्यक्तः, स्वयं गोचरतामुपगत इति भावः, अभिव्यक्त हुआ।
हिरण्यगर्भः	—	षड्गुण, ऐश्वर्य, समग्रता, धर्म, यश, श्री, ज्ञान-वैराग्य से सम्पन्न अनिरुद्ध भगवान् जो हैम अण्ड से प्रादुर्भूत हुआ, वेद में हिरण्यगर्भ कहलाता है।
छन्दसि	—	वेदे, वेद में।
आदिभूतत्वात्	—	सर्वतः प्रथमममभिव्यक्तत्वाद्, सर्वप्रथम अभिव्यक्त होने के कारण सूर्य को आदित्य कहा जाता है।
प्रसूत्या	—	जगदुत्पत्तितया, जगत् की उत्पत्ति के द्वारा।
विश्वमये रथे	—	ब्रह्माण्डात्मके रथे, ब्रह्माण्डस्वरूपी रथ पर।
संवत्सरात्मकम्	—	द्वादशमासात्मकं वर्षरूपं चक्रं कृत्वा, बारह महीनों वाले वर्ष रूपी चक्र को करके (इसीलिए एक वर्ष में रवि बारह राशियों का भोग करता है)।
छन्दांस्यश्वान्	—	छन्दांसि गायत्र्युष्णिगनुष्टुब्बृहतीपङ्क्तित्रिष्टुब्जगती-रूपाणि सप्ताश्वान्, गायत्री, उष्णिक्, अनुष्टुप्, बृहती, पङ्क्ति, त्रिष्टुप्, जगती - छंद रूपी सात अश्वों को।
युक्त्वा	—	संयोज्य, जोड़कर।
सृष्ट्याम्	—	विश्वरचनायाम्, विश्व की रचना में।
जज्ञे	—	प्रादुरभूत्, प्रादुर्भूत हुआ।
अक्ष्णोः	—	नेत्रद्वयत : दो नेत्रों से।
खम्	—	आकाशम्, आकाश को।

गुणैकवृद्ध्या — गुणानामेकैकवृद्धिक्रमेण, गुणों में एक-एक वृद्धि के क्रम के द्वारा।

महाभूतानि — आकाश, वायु, अग्नि, जल और पृथ्वी इस क्रम से शब्द, स्पर्श, व गंध इन महाभूतों के प्रधान विषय हैं।

जज्ञिरे — समुद्भूतानि, उत्पन्न हुए।

अग्नीषोमौ — अग्निश्च सोमश्चेत्यग्नीषोमाविति छान्दसिकः प्रयोगः। अग्नि व सोम यह वैदिक प्रयोग है। सूर्य अग्निस्वरूप होने से तेज की राशि है तथा चन्द्रमा सोम स्वरूप है।

अङ्गारकादयः — भौमादयः पञ्चताराग्रहाः, मंगल आदि पाँच तारा ग्रह।

तेजोभूखाम्बुवातेभ्यः — तेजोऽग्नितत्त्वं तस्माद्भौमः, भूः पृथ्वी ततो बुधः, खमाकाशं ततो बृहस्पतिः, अम्बु जलं तस्माच्छुक्रः, वातो वायुस्तस्माच्छनिरुत्पन्नः इति। तेजरूपी अग्नि तत्त्व से मंगल, फिर पृथ्वी, फिर बुध, आकाशस्वरूप बृहस्पति,जलस्वरूप से शुक्र तथा वायु से शनि।

सुषिरम् — अनन्तावकाशं छिद्रमिवास्तीति शेषः, अनंत अवकाश रूपी छिद्र सा है।

कटाहद्वितयस्येव सम्पुटम् — तुल्यप्रमाणकटाहद्वयस्य संयोगेन यथा गोलाकृतिरन्तश्छिद्रा भवति तथैवेदं ब्रह्माण्डमिति। समान प्रमाण के दो कटाह (कपालद्वय) के संयोग से जो गोल की आकृति बनती है और उसमें अनंत छिद्र हैं, उसी प्रकार यह ब्रह्माण्ड है।

परिधिः	–	वर्तुलाकारब्रह्माण्डस्य यः परिणाहः सः, गोलाकार ब्रह्माण्ड के आसपास का घेरा।
व्योमकक्षा	–	व्योम्नः, आकाशस्य कक्षा, आकाशकक्षा।
मन्दामरेज्य-भूपुत्र-सूर्य-शुक्रेन्दुजेन्दवः	–	मन्दः शनिः, अमरेज्य, देवता जिसकी पूजा करते हैं अर्थात् बृहस्पति, भूपुत्र- पृथ्वी का पुत्र मंगल, सूर्य, शुक्र, इंदुज– चंद्रमा का पुत्र बुध तथा अंत में चंद्रमा।

अभ्यासः

1. संस्कृतभाषया उत्तराणि लिखत

क) अस्मिन् पाठे कः प्रष्टा कः च उत्तरदाता?

ख) अपः कः सृष्टवान्?

ग) हैमम् अण्डं कथम् अभवत्?

घ) सूर्यः कः उच्यते?

ङ) सूर्यः किं युक्त्वा सर्वदा पर्यटति?

च) व्योमकक्षा का अभिधीयते?

छ) के के ग्रहाः व्योमकक्षायाम् भ्रमन्ति?

ज) काः सप्त पातालभूमयः?

झ) अयं पाठः कस्माद् ग्रन्थाद् उद्धृतः?

2. अधोलिखितानामाशयम् स्पष्टीकुरुत

क) हिरण्यगर्भो भगवानेष च्छन्दसि पठ्यते।

ख) गुणैकवृद्ध्या पञ्चेति महाभूतानि जज्ञिरे।

ग) तेजोभूखाम्बुवातेभ्यः क्रमशः पञ्च जज्ञिरे।

3. रिक्तस्थानानि पूरयत

क) सङ्कर्षणः.................. सृष्ट्वा वीर्यम् अवासृजत्।

ख) अथ सृष्ट्यां ब्रह्मा .... चक्रे।

ग) कटाहद्वितयस्येव सम्पुटं ....।

घ) ब्रह्माण्डमध्ये परिधिः .... कथ्यते।

4. क) सृष्टिक्रमं स्वभाषया वर्णयत।

ख) ब्रह्माण्डं किं रूपमस्ति इति स्पष्टीकुरुत।

5 अधोलिखितपदानाम् अर्थमेलनं क्रियताम्

पदानि	**अर्थाः**
भूः	सूर्यः
हैमम्	दिन-रात्री
आदित्यः	पृथिवी
अहोरात्रम्	आकाशः
अङ्गारकः	शनिः
व्योम	बुधः
मन्दः	मङ्गलः
इन्दुजः	स्वर्णम्

सप्तमः पाठः

ऋतुचर्या

यह पाठ महर्षि अग्निवेश द्वारा रचित **चरकसंहिता** नामक आयुर्वेद के ग्रंथ से संकलित किया गया है। इस ग्रंथ के छठे अध्याय में विभिन्न ऋतुओं में आहार से संबंधित नियम बताए गए हैं। अपनी दिनचर्या में किंचित् परिवर्तन करके व्यक्ति दीर्घ आयु तथा स्वस्थ जीवन को प्राप्त करता है। संकलित पद्यों में हेमंत, शिशिर, वसंत, ग्रीष्म, वर्षा और शरद् इन छः ऋतुओं में मनुष्य को अपनी भोजनचर्या किस प्रकार की रखनी चाहिए, इसका विवेचन किया गया है।

हेमन्तः

गोरसानिक्षुविकृतीर्वसां तैलं नवौदनम्।
हेमन्तेऽभ्यस्यतस्तोयमुष्णं चायुर्न हीयते।।1।।
वर्जयेदन्नपानानि वातलानि लघूनि च।
प्रवातं प्रमिताहारमुदमन्थं हिमागमे।।2।।

शिशिरः

हेमन्तशिशिरौ तुल्यौ शिशिरेऽल्पं विशेषणम्।
रौक्ष्यमादानजं शीतं मेघमारुतवर्षजम्।।3।।
तस्माद्धैमन्तिके सर्वः शिशिरे विधिरिष्यते।
निवातमुष्णं त्वधिकं शिशिरे गृहमाश्रयेत्।।4।।

कटुतिक्तकषायाणि वातलानि लघूनि च।
वर्जयेदन्नपानानि शिशिरे शीतलानि च।।5।।

वसन्तः

वसन्ते निचितः श्लेष्मा दिनकृद्भाभिरीरितः।
कायाग्निं बाधते रोगांस्ततः प्रकुरुते बहून्।।6।।
तस्माद्वसन्ते कर्माणि वमनादीनि कारयेत्।
गुर्वम्लस्निग्धमधुरं दिवास्वप्नं च वर्जयेत्।।7।।

ग्रीष्मः

मयूखैर्जगतः स्नेहं ग्रीष्मे पेपीयते रविः।
स्वादु शीतं द्रवं स्निग्धमन्नपानं तदा हितम्।।8।।
घृतं पयः सशाल्यन्नं भजन् ग्रीष्मे न सीदति।
लवणाम्लकटूष्णानि व्यायामं च विवर्जयेत्।।9।।

वर्षा

भूवाष्पान्मेघनिस्यन्दात् पाकादम्लाज्जलस्य च।
वर्षास्वग्निबले क्षीणे कुप्यन्ति पवनादयः।।10।।
व्यक्ताम्ललवणस्नेहं वातवर्षाकुलेऽहनि।
विशेषशीते भोक्तव्यं वर्षास्वनिलशान्तये।।11।।

शरद्

वर्षाशीतोचिताङ्गानां सहसैवार्करश्मिभिः।
तप्तानामाचितं पित्तं प्रायः शरदि कुप्यति।।12।।
तत्रान्नपानं मधुरं लघु शीतं सतिक्तकम्।
पित्तप्रशमनं सेव्यं मात्रया सुप्रकाङ्क्षितैः।।13।।

शारदानि च माल्यानि वासांसि विमलानि च।
शरत्काले प्रशस्यन्ते प्रदोषे चेन्दुरश्मयः।।14।।

शब्दार्थाः टिप्पण्यश्च

नवौदनम्	–	नये चावल।
वातलानि	–	वातकारक।
रौक्ष्यं	–	रूखा।
निचितः	–	बढ़ा हुआ।
श्लेष्मा	–	कफ।
वमनादीनि	–	उल्टी आदि।
दिवास्वप्नम्	–	दिन में सोना।
मयूखैः	–	किरणों के द्वारा।
पेपीयते	–	बार-बार अथवा अत्यधिक पीता है।
सशाल्यन्नम्	–	धान सहित अन्न।
अनिलशान्तये	–	वायु की शांति के लिए।
अर्करश्मिभिः	–	सूर्य की किरणों के द्वारा।
प्रदोषे	–	रात्रि में।

सन्धिविच्छेदः

नवौदनम्	=	नव + ओदनम्
चायुः	=	च + आयुः
शिशिरेऽल्पम्	=	शिशिरे + अल्पम्
विधिरिष्यते	=	विधिः+ इष्यते
भाभिरीरितः	=	भाभिः + ईरितः
सशाल्यन्नम्	=	सशालि + अन्नम्

सहसैवार्करश्मिभिः = सहसा + एव + अर्करश्मिभिः
चेन्दुरश्मयः = च + इन्दुरश्मयः

अभ्यासः

1. **संस्कृतेन उत्तराणि देयानि**
   - क) अयं पाठः कस्माद् ग्रन्थात् सङ्कलितः कश्च तस्य प्रणेता?
   - ख) कति ऋतवः भवन्ति? कानि च तेषां नामानि?
   - ग) शिशिरे किं किं वर्जनीयम्?
   - घ) वसन्ते कायाग्निं कः बाधते?
   - ङ) ग्रीष्मे कीदृशम् अन्नपानं हितं भवति?
   - च) कस्मिन् ऋतौ पवनादयः कुप्यन्ति?
   - छ) शरदृतौ पित्तप्रशमनाय किं किं सेव्यम् अस्ति?

2. **रिक्तस्थानपूर्तिः क्रियताम्**
   - क) हिमागमे .... लघूनि च अन्नपानानि वर्जयेत्।
   - ख) शिशिरे निवातम् .... च गृहम् आश्रयेत्।
   - ग) .... दिवास्वप्नं वर्जयेत्।
   - घ) ग्रीष्मे घृतं पयः .... भजन् नरः न सीदति।
   - ङ) .... विमलानि वासांसि प्रशस्यन्ते।

3. **व्याख्यायन्ताम्**
   - क) हेमन्तशिशिरौ तुल्यौ शिशिरेऽल्पं विशेषणम्।
   - ख) मयूखैर्जगतः स्नेहं ग्रीष्मे पेपीयते रविः।
   - ग) शरत्काले प्रशस्यन्ते प्रदोषे चेन्दुरश्मयः।

4. **ऋतुचर्यापाठम् अधिकृत्य प्रत्येकम् ऋतौ किं किं करणीयम् किं किं च न करणीयम् इति सुस्पष्टयत।**

5. **अधोलिखितानि विग्रहपदानि आधृत्य समस्तपदानि रचयत**

	विग्रहपदानि	समस्तपदानि	समास नाम
यथा –	नवम् ओदनम्	नवौदनम्	कर्मधारय समासः
क)	अन्नानि च पानानि च	....	द्वन्द्वः
ख)	हेमन्तः च शिशिरः च	....	द्वन्द्वः
ग)	हिमस्य आगमे	....	ष.तत्पुरुषः
घ)	कायस्य अग्निम्	....	ष. तत्पुरुषः
ङ)	अर्कस्य रश्मिभिः	....	ष. तत्पुरुषः

6. **अधोलिखितपदानामर्थमेलनं क्रियताम्**

	पदानि	अर्थ
क)	श्लेष्मा	हवारहित
ख)	रौक्ष्यम्	बढ़ा हुआ (जमा हुआ)
ग)	निवातम्	वात
घ)	निचितः	भारी
ङ)	पवनः	हल्का
च)	गुरु	वस्त्र
छ)	लघु	रूखापन
ज)	वासांसि	कफ

7. **अधोलिखितपदानाम् विपरीतार्थकपदैः सह मेलनं क्रियताम्**

पदानि	*विपरीतार्थकपदानि*
उष्णम्	अधिकम्
सीदति	शीतानाम्
तप्तानाम्	प्रसीदति
गुरु	शीतम्
अल्पम्	लघु

अष्टमः पाठः

गणितीयविधिः

प्रस्तुत पाठ **भास्कराचार्य** की पुस्तक **लीलावती** से लिया गया है। विज्ञान का कोई भी शोध-तथ्य बिना गणित के अपने स्वरूप को स्पष्ट नहीं कर सकता। वैज्ञानिक, तार्किक एवं खोजपरक बुद्धि के मूल में गणित की विधियों में प्रवीणता है जो शीघ्र हल को ढूँढ़ निकालने के लिए अपरिहार्य है। गणित को प्रायः शुष्क विषय माना जाता है, लेकिन लीलावती इसका अपवाद है। व्याकरण, छंद व अलंकार से अंलकृत होकर खेल-खेल में पद्य के माध्यम से गणितीय प्रक्रिया को सीखा भी जा सकता है ऐसा इस पाठ से स्पष्ट होता है। प्रस्तुत अंश में संकलन एवं व्यवकलन विधि, गुणनविधि, वर्गविधि, घनविधि तथा अंत में क्षेत्रव्यवहार का गणित उदाहरण सहित स्पष्ट किया गया है।

अये बाले लीलावति मतिमति ब्रूहि सहितान्
द्विपञ्चद्वात्रिंशत्-त्रिनवतिशताष्टादश दश।
शतोपेतानेतानयुतवियुतांश्चापि वद मे
यदि व्यक्ते युक्तिव्यवकलनमार्गेऽसि कुशला।।1।।

(अभिन्नपरिकर्माष्टकम् - संकलनव्यवकलनविधिः)

बाले बालकुरङ्गलोलनयने लीलावति प्रोच्यतां
पञ्चत्र्येकमिता दिवाकरगुणा अङ्का कति स्युर्यदि।
रूपस्थानविभागखण्डगुणने कन्याऽसि कल्याणिनि
च्छिन्नास्तेन गुणेन ते च गुणिता जाताः कति स्युर्वद।।2।।

(अभिन्नपरिकर्माष्टकम् गुणनविधिः)

सखे नवानां च चतुर्दशानां ब्रूहि त्रिहीनस्य शतत्रयस्य।
पञ्चोत्तरस्याप्ययुतस्य वर्गं जानासि चेद्वर्गविधानमार्गम्।।3।।

(वर्गविधिः)

नवघनं त्रिघनस्य घनं तथा कथय पञ्च घनस्य घनं च मे।
घनपदं च ततोऽपि घनात् सखे यदि घनेऽस्ति घना भवतो मतिः।।4।।

(घनविधिः)

कोटिश्चतुष्टयं यत्र दोस्त्रयं तत्र का श्रुतिः।
कोटिं दोः कर्णतः कोटिश्रुतिभ्यां च भुजं वद।।
साङ्घ्रित्रयमितो बाहुर्यत्र कोटिश्च तावती।
तत्र कर्णप्रमाणं किं गणक? ब्रूहि मे द्रुतम्।।5।।

(क्षेत्रव्यवहारः भुजज्ञानम्)

शब्दार्थाः टिप्पण्यश्च

मतिमति	–	बुद्धिमति।
ब्रूहि	–	कथय, कहो।
सहितान्	–	योगफलान्, जोड़ कर प्राप्त हुए फल को।
द्विपञ्चद्वात्रिंशत्त्रिनवतिशत	–	द्वि (2), पञ्च (5), द्वात्रिंशत् (32), त्रिनवतिशत (193)।
अष्टादशदश	–	अष्टादश (18), दश (10)
शतोपेतान्	–	100 में जोड़कर।
अयुत	–	10,000
व्यवकलन	–	विशोधन, घटाना।

उपपत्ति — समानजात्योरेव योगान्तरं भवति इति नियमादेकादिस्थानीयाङ्केष्वेकादि स्थानीयाङ्कस्य योगो वियोगो वा समुचितः।

उदाहरण – यहाँ क्रम व उत्क्रम रीति से योग व अन्तर करने की विधि बतायी गयी है। जैसे 325 में 125 को जोड़ना है तो पहले 325 के नीचे इकाई के स्थान में 5 को और दहाई के स्थान पर 2 को और फिर सैंकड़े की जगह 1 को लिखा तो 325 ऐसा हुआ।
125

अब पाँच में पाँच को जोड़ा तो दस हुआ, दस का शून्य लिखकर शेष बचे हुए एक को दहाई वाले अंकों में जोड़ा तो 2+2 =4 , 4+1=5 हुआ, इसको शून्य के बाँई तरफ रख (लिख) देंगे। बाद में सैंकड़े स्थान वाले अंकों को जोड़ा तो 3+1= 4 हुआ। यह क्रमरीति से आया **योगफल है।**

उत्क्रम रीति से योग करने के लिए 325 के नीचे 125 को रखा। यहाँ बायीं तरफ से 3 के नीचे 1 है, अतः दोनों के योगफल 4 को अलग लिख दिया, इसके बाद 2 में 2 को जोड़ने से 4 हुआ, उसको पहले वाले 4 के दायीं तरफ रखा। अब इकाई वाले अंकों का योग किया तो दस हुआ। दस का शून्य पहले 4 की दाहिनी तरफ रख दिया और एक को शून्य की बायीं तरफ वाले 4 के ऊपर लिख दिया तो ऐसा हुआ $\overset{1}{4}40$, इनका योग किया तो 450 पहले **योगफल** के समान हुआ।

क्रमरीति :	उत्क्रमरीति :	
325	325	1
+ 125	125	440
450	450	450

योगफल – 450

व्यवकलन

क्रम रीति से अन्तर करने के लिए 325 के नीचे 125 को रख दिया। बाद में दाहिनी तरफ के ऊपर वाले 5 में नीचे का 5 घटाया तो शून्य बचा, उसको लिख लें। फिर 2 में से 2 को घटाया तो शेष शून्य को पहले के शून्य से बायीं तरफ लिखा, अन्त में तीन में से 1 घटाया तो 2 शेष रहा, इसको लिखे हुए शून्य के बायीं तरफ लिख दिया तो उत्तर हुआ - 200

उत्क्रम रीति से घटाना हो तो घटने वाले अंकों को ऊपर लिखो और जिसमें से घटेगा उसको नीचे लिखकर बायीं ओर से घटाना प्रारम्भ करो। जैसे 325 में से 135 घटाना है तो 325 के ऊपर 135 को लिखा यथा 135। अब नीचे की बायीं तरफ में जो 3 है उसमें से ऊपर लिखे
325
एक को घटाया तो शेष 2 बचा। लेकिन आगे 2 में 3 नहीं घटेगा, अतः शेष 2 को लिखा। दहाई के स्थान में से एक को लेकर 2 में जोड़ा तो हुआ 10+2=12 इसमें से ऊपर वाले 3 को घटाया तो शेष 9 रहा। इसको पहले शेष की दाहिनी तरफ लिख दिया क्योंकि 5 में से 5 घट जाएगा, 5 में से 5 को घटाने पर शून्य शेष रहा। इसको लिखित शून्य से दाहिनी तरफ रखा तो अंतर 190 हुआ।

विशेष : Modern Mathematics में संकलन को Addition और व्यवकलन को Subtraction कहा जाता है।

गुणनविधिः

बालकुरंगलोलनयने — बाल कुरंग (हरिण) के समान चंचल नेत्रों वाली।
प्रोच्यताम् — कथ्यताम्, कहो।
पञ्चत्र्येकमिता — पञ्च (5), त्रि (3), एक (1) अङ्कानां वामतो गतिः अतः 135
दिवाकरगुणाः — 12 से गुणा करने पर (द्वादश आदित्य माने जाते हैं)

रूपस्थानविभाग-खण्डगुणने — रूप, स्थान विभाग व खण्ड गुणन की रीति से।

छिन्नाः — भक्ताः, भाग देने पर।

गुणिताः — गुणा किए गए अंक।

उपपत्ति —

1. गुणयितुं योग्यो गुण्यस्तथा येन गुण्यते स गुणक इति। गुणकस्थानस्थितानां गुण्यानां योगो हि गुणनफलं, तत्तु गुण्यगुणकयोर्घात-तुल्यमत उपपन्नः प्रथमः प्रकारः।

2. अत्र यदि च = प ×फ। तदा गुणनफलं अ×च = अ×(प+फ) =अ×प+अ×फ एतेनोपपन्नः द्वितीयः प्रकारः।

3. कल्प्यते गु =गुण्यः। गुणक =प। इसलिए गुणनफलं = गु ×प अत्र यदि प/अ =क, तदा प = अ×क। इसलिए गुणनफलं गु×अ×क,अत उपपन्नस्तृतीयः प्रकारः।

4. यदि गुणकः = 10अ + क, तदा गु.फ.=गुण्य ×(10 अ+क) = गुण्य × 10 अ + गुण्य ×क। अत्र क एकस्थानीयस्तथा 'अ' दशस्थानीयस्तयोर्गुण्यगुणितयोः स्थानवशेन योगो गुणनफलसमो दृश्यते, अत उपपन्नश्चतुर्थः प्रकारः।

उदाहरण

1. यदि गुण्य 135 हो और गुणक 12 तब गुणनफल प्रथम प्रकार से

$$\begin{array}{r} 135 \times 12 \\ \hline 270 \\ +\ 135\ \\ \hline 1620 \\ \hline \end{array}$$ गुणनफल

2. गुणरूपविभाग में गुणक के खण्ड कर दो यथा 12 = 8+4, दोनों खण्डों से अलग-अलग गुणा कर, दोनों गुणनफलों को जोड़ दो वह ही उत्तर होगा। यथा -

$$\begin{array}{r} 135 \\ \times\ 8 \\ \hline 1080 \end{array} \qquad \text{तथा} \qquad \begin{array}{r} 135 \\ \times\ 4 \\ \hline 540 \end{array}$$

दोनों का योग करने पर

1080 + 540 =1620 गुणनफल होगा।

इस प्रकार गुणक को सुविधानुसार कितने ही भागों में बाँटा जा सकता है।

यथा =12 = 4+4+4

12 = 3+3+3+3

12 = 2+2+2+2+2+2

12 = 10+2 इत्यादि।

3. स्थानविभाग रीति से गुणक के दो खण्ड कर दो यथा 1 और 2 दोनों से गुण्य को पृथक्-पृथक् गुणा करो तथा गुणनफलों को स्थानयुति से जमा कर दो यथा –

$$\begin{array}{r} 135 \\ \times\ 1 \\ \hline 135 \end{array} \qquad \begin{array}{r} 135 \\ \times\ 2 \\ \hline 270 \end{array}$$

स्थानयुति करने पर –

$$\begin{array}{r} 270 \\ +\ 135 \\ \hline 1620 \end{array}$$ गुणनफल

विशेष : Modern Mathematics में गुणनविधि को Multiplication कहा जाता है।

वर्गविधिः

पञ्चोत्तरस्याप्ययुतस्य = 10005

वर्गविधानमार्गम् = वर्ग करने की विधि को।

उपपत्तिः - न्यासः 1, 9, 14, 297, 10005, एषां यथोक्तकरणेन जाता वर्गाः – 81, 196, 88209, 100100025 अथवा नवानां खण्डे (4और 5) अनयोराहति- 20, द्विर्निध्नी (40) तत्खण्डवर्गैक्येन (41),युता जाता सैव कृतिः = 81

उदाहरण – पहली रीति से –

$9^2 = 9 \times 9 = 81$

$14^2 = 14 \times 14 = 196$

$297^2 = 297 \times 297 = 88209$

$10005^2 = 10005 \times 10005 = 100100025$

दूसरी विधि से –

यदि 297 का वर्ग करना है तो पहले अन्त्य अंक 2 के वर्ग 4 को 2 के ऊपर रखा। अब द्विगुणित अंतिम अंक 4 से आगे के 9 और 7 को अलग–अलग गुणा कर उनके ऊपर रख दिया। बाद में 2 को छोड़कर शेष 97 को आगे उठाकर रखा। फिर 9 के वर्ग 81 को उसके ऊपर निवेश किया। अब द्विगुणित अंतिम अंक 18 को 7 से गुणा करने पर 126 हुआ। इसमें 6 को 7 के ऊपर, 2 को 9 के ऊपर और 1 को उसके बाईं तरफ वाले अंक के ऊपर रखा फिर 9 को छोड़ा ओर 7 को

योग करने की रीति
1
82
3214
46869
88209 – गुणनफल वर्ग करने पर

उठाकर आगे लिख कर उसका वर्ग 49 को उसके ऊपर लिख दिया। आगे अंक नहीं है, अतः क्रिया समाप्त हो गयी। शेष में सबों को जोड़ने पर 88209 वर्ग हुआ।

विशेष – Modern Mathematics में इसे square कहते हैं।

घनविधिः

नवघनम् — नौ का घन

उपपत्तिः — न्यासः 9, 27 व 125 जाताः क्रमेण घनाः 729, 19683, 1953125 अथवा राशि = 9 अस्य खण्डे 4, 5; आभ्यां राशिर्हतः =180, त्रिनिघ्नश्च 540 खण्डघनैक्येन 189 युतो जातो घनः 729 वा राशि 9 अस्य मूलम् 3, घन 27 अस्य वर्गो नवानां घनः = 729 यो वर्गघनः स एव वर्गमूलघनवर्गः। बीजगणितेऽस्योपयोगः।

उदाहरण – पहली रीति से –

$9^3 = 9 \times 9 \times 9 = 729$

$27^3 = 27 \times 27 \times 27 = 19683$

$125^3 = 125 \times 125 \times 125 = 1953125$

दूसरी रीति से –

27 का घन करना है, तो वहाँ अन्त्य अंक 2 का घन 8 को लिखकर अंतिमांक 2 के वर्ग 4 को त्रिगुणित आदिम अंक $(7 \times 3) = 21$ से गुणा करने पर $(21 \times 4) = 84$ हुआ। इसको स्थानांतर करके अर्थात् 8 घन के ऊपर 8 लिखकर उसके दायें भाग में एक स्थान बढ़ाकर 4 लिखा। बाद में आदिम अंक 7 के वर्ग 49 को त्रिगुणित अंतिमांक $(3 \times 2) = 6$ से गुणा करने पर 294 हुआ। इसको उक्त क्रम से लिखा। अंत में आदिम अंक 7 का घन $7 \times 7 \times 7 = 343$ को रखकर सबों को

स्थानांतर से जोड़ने पर 19683 हुआ।

जोड़ने की विधि

$$\begin{array}{r} 23 \\ +\ 894 \\ +\ 8443 \\ \hline 19683 \end{array}$$

क्षेत्रव्यवहारः

कोटिश्चतुष्टयम् – कोटि 4 है।

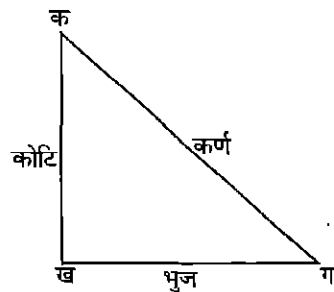
दोस्त्रयम् भुज 3 है।

साङ्घ्रित्रयमितो $3\frac{1}{4}$

बाहु भुज

उपपत्तिः स्पष्टमेव।

उदाहरण – मान लो क ख ग एक समकोण त्रिभुज (Right Angle Triangle) है तो इसमें कख लम्ब (Perpendicular) को कोटि (Perpendicular) कहेंगे तथा खग को भुज (Base) कहेंगें तथा कग को कर्ण (Hypotenuse) कहेंगे। आधुनिक गणित में उन्हें Trigonometric Ratios कहते हैं।

1. यदि कोटि 4 हो, भुज 3 हो तो कर्ण का मान निकालने के लिए भुजवर्ग करेंगे – 3×3= 9,फिर कोटिवर्ग 4×4=16 इन दोनों का योग 16+9=25 तथा इसका वर्गमूल (Square Root) =5 कर्ण का मान होगा।

2. यदि कर्ण 5 है, भुज 3 है तो कोटि के मान को निकालने के लिए पहले की तरह दोनों का वर्ग करेंगे - $5 \times 5 = 25$ तथा $3 \times 3 = 9$ घटाने पर $25 - 9 = 16$, वर्गमूल करने पर 4 कोटि का मान होगा।

3. यदि कर्ण 5 तथा कोटि 4 है तो भुज के मान के लिए दोनों का वर्ग करके $5 \times 5 = 25$, $4 \times 4 = 16$ घटाने पर $25 - 16 = 9$ वर्गमूल करने पर 3, भुज का मान होगा।

4. यदि भुज $3\frac{1}{4}$ हो और कोटि भी उतनी ही हो तो कर्ण का मान

भुजवर्ग = $3\frac{1}{4} \times 3\frac{1}{4} = \frac{13}{4} \times \frac{13}{4} = \frac{169}{4}$

कोटि वर्ग = $3\frac{1}{4} \times 3\frac{1}{4} = \frac{13}{4} \times \frac{13}{4} = \frac{169}{4}$

जोड़ने पर = $\frac{169}{4} + \frac{169}{4} = \frac{338}{16} = \frac{169}{8}$

इसलिए कर्ण = $\frac{169}{8}$, मूल न होने से करणी गत अवगङ्क ही कर्ण का मान होगा।

अभ्यासः

1. संस्कृतमाश्रित्य उत्तराणि लिखत

क) सङ्कलनविधिं स्पष्टीकुरुत।

ख) रूपस्थानविभागखण्डगुणने - इत्यस्याशयं स्पष्टं कुरुत।

ग) वर्गः कथं भवति?

घ) भुजानयनं कथं क्रियते?

ङ) प्रस्तुतः पाठः कस्माद् ग्रन्थात् सङ्कलितः? कश्च तस्य लेखकः?

2. रिक्तस्थानानां पूर्तिः करणीया

   क) $4^3 =$ ....

   ख) $259^2 =$ ....

   ग) कोटिः =10, भुज = 8, तत्र कर्णः ....

   घ) 12 X (50+20) = ...

   ङ) 525 + 223 = ...

   च) 802 - 105 = ...

3. कर्णप्रमाणम् कथं ज्ञायते? सोदाहरणं स्पष्टीक्रियताम्।

4. घनविधिः सोदाहरणं व्याख्यायताम्।

5. स्पष्टीक्रियन्ताम् – गुण्यः, गुणकम्, व्यवकलनम्, भुजः, कर्णः, कोटिः।

नवमः पाठः

प्राचीनं-यन्त्र-विज्ञानम्

प्रस्तुत पाठ **श्रीमद्भास्कराचार्य** के ग्रंथ **सिद्धान्तशिरोमणि** के **गोलाध्याय** से लिया गया है, जिसमें गोल की महत्ता वैज्ञानिक विधियों से प्रतिपादित की गयी है। प्राचीनकाल में समय की इकाई के सूक्ष्मातिसूक्ष्म स्वरूप को जानने के लिए यंत्रों की सहायता ली जाती थी। इसके लिए वेधशालाओं (Observatories) का निर्माण किया जाता था। प्रस्तुत अंश में काल-ज्ञान के लिए दस यंत्रों का विवेचन है, जिनमें धी-यंत्र सर्वोत्तम है। यद्यपि इसमें कहे गए यंत्र इतने सूक्ष्म काल-भेद को प्रस्तुत नहीं करते, परंतु प्राचीन भारतीय विद्वानों की यांत्रिकी प्रवृत्ति (Technical sense) की ओर संकेत अवश्य करते हैं, जो कि बाद में पुष्पित व पल्लवित हुई।

दिनगतकालावयवा ज्ञातुमशक्या यतो विना यन्त्रैः।
वक्ष्ये यन्त्राणि ततः स्फुटानि सङ्क्षेपतः कतिचित्।।1।।
गोलो नाडीवलयो यष्टिः शङ्कुर्घटी पारमार्थिकं यन्त्रम्।
चापं तुर्यं फलकं धीरेकं पारमार्थिकं यन्त्रम्।।2।।

गोलयन्त्रम्

अपवृत्तगरविचिह्नं क्षितिजे धृत्वा कुजेन संसक्ते।
नाडीवृत्ते बिन्दुं कृत्वा धृत्वाऽथ जलसनं क्षितिजम्।।3।।

रविचिह्नस्य च्छाया पतति कुमध्ये यथा तथा विधृते।
उडुगोले कुजबिन्द्वोर्मध्ये नाड्यो द्युयाताः स्युः ।।4।।

नाडीवलयम्

अपवृत्ते कुजलग्ने लग्नं चाथो खगोलनलिकान्तः।
भूस्थं ध्रुवयष्टिस्थं चक्रं षष्ट्या निजोदयैश्चाड्.क्यम् ।।5।।
व्यस्तैर्यष्टीभायामुदयेऽर्कं न्यक्ष्य नाडिका ज्ञेयाः।
इष्टच्छायासूर्यान्तरेऽथ लग्नं प्रभायां च।।6।।
केनचिदाधारेण ध्रुवाभिमुखकीलकेऽत्र धृते।
अथवा कीलच्छायातलमध्ये स्युर्नता नाड्यः।।7।।

घटिका

घटदलरूपा घटिका घटिका ताम्री तले पृथुच्छिद्रा।
द्युनिशनिमज्जनमित्या भक्तं द्युनिशं घटीमानम्।।8।।

शड्.कुः

समतलमस्तकपरिधिर्भ्रमसिद्धो दन्तिदन्तजः शड्.कुः।
तच्छायातः प्रोक्तं ज्ञानं दिग्देशकालानाम्।।9।।
चक्रं चक्रांशाड्.कं परिधौ श्लथ शृड्.खलादिकाधारम्।
धात्री त्रिभ आधारात् कल्प्या भार्धेऽत्र खार्धे च।।10।।
तन्मध्ये सूक्ष्माक्षं क्षिप्त्वाऽर्काभिमुखनेमिकं धार्यम्।
भूमेरुन्नतभागास्तत्राक्षच्छायया युक्ता ।।11।।
तत्खार्धान्तश्च नता उन्नतलवसंगुणीकृतं द्युदलम्।।
द्युदलोन्नतांशभक्तं नाड्यः स्थूलाः परैः प्रोक्ताः।।12।।

चापं तुर्यं च

दलीकृतं चक्रमुशन्ति चापं कोदण्डखण्डं खलु तुर्यगोलम्।।13।।

फलकम्

दृङ्मण्डलेऽत्र स्फुटकाल उक्तः सुखेन नान्यैर्यतितं मयाऽतः।
सद्गोलयुक्तेर्गणितस्य सारं स्पष्टं प्रवक्ष्ये फलकाख्ययन्त्रम्।।14।।

शब्दार्थाः टिप्पण्यश्च

दिनगतकालावयवाः — दिनगताः सूर्योदयकालादभीष्टतद्दिनीयकाले ये कालावयवाः घट्यादिरूपास्ते। सूर्योदय काल से अभीष्ट दिन के काल के अवयव-घटी आदि का ज्ञान। (अभिप्राय यह है कि स्थूल व सूक्ष्म भेद से समय की आनन्त्योन्मुखी गति का ज्ञान करना सम्भव नहीं है।)

स्फुटानि — सूक्ष्माणि, सूक्ष्म।

यन्त्राणि — कालज्ञान के लिए मनुष्य द्वारा निर्मित भौतिक यंत्र।

पारमार्थिकं यंत्रम् — आध्यात्मिक यंत्र (सर्वत्र गमनशील, सर्वज्ञता बोधक यंत्र)

अपवृत्तगरविचिह्नम् — खगोलान्तर्क्षगोलस्थक्रान्तिवृत्ते मेषादेस्तत्कालिकस्पष्टार्कयोगं दत्त्वा कृतचिन्हमित्यर्थः। खगोल के अंदर नक्षत्र चक्र में अथवा क्रान्तिवृत्त में जहाँ मेषादि राशि स्पष्ट सूर्य द्वारा भुक्त हो, वहाँ चिन्ह लगा दो।

क्षितिजे — खगोलबद्धक्षितिजप्राग्भागसमसूत्रे, खगोल से बद्ध क्षितिज के पूर्व भाग में।

धृत्वा — कृत्वा, करके।

कुजेन — क्षितिजवृत्तप्राग्भाप्रदेशेन, क्षितिज वृत्त के पूर्व प्रदेश द्वारा।
संसक्ते — समसूत्रतया संलग्ने।
नाडीवृत्ते — विषुवत्प्रदेशे।
बिन्दुम् — चिह्नम्।
जलसनम् — जलं यथा समानमस्ति नोच्चावचं तद्वत्, जल जैसे समान होता है वैसे ही, न ऊँचा न नीचा।
छाया — आकाशस्थसूर्यबिम्बजनिता छाया, आकाश में स्थित सूर्य के बिम्ब से उत्पन्न हुई छाया।
कुमध्ये — भूगोलमध्यगर्भे, भूगोल के मंध्य भाग में।
उडुगोले — नक्षत्रगोले, नक्षत्र चक्र में।
कुजलग्ने — क्रान्तिवृत्ते क्षितिजसंलग्ने लग्नम्, क्रान्ति वृत्त में क्षितिज के लगने पर।
खगोलनलिकान्तः — नलिकाद्वयप्रोतं खगोलमुक्तदिशा कृत्वा तन्नलिकयोः मध्य इत्यर्थः, दो नलिकाओं द्वारा खगोल की दिशा जानकर, उन नलिकाओं के मध्य।
ध्रुवयष्टिस्थम् — नलिकाद्वयप्रोताग्रध्रुवयष्टिप्रोतं चक्रं चारुदारुनिर्मितमिष्टव्यासार्धजनितपरिधिप्रमाणम्। इष्ट सुदृढ़ लकड़ी की।
यष्टी भा — यष्टिछाया।
उदये — उदयकाल में।
अर्कं न्यक्ष्य — सूर्य को स्थापित करके।
ध्रुवाभिमुखकीलके — अभीष्ट समय में कील की (छाया)।
तलमध्ये — यंत्र, तल के मध्य में।
नाड्यः — घट्यः, घटियाँ।
घटदलरूपा — दो बड़े जलपूर्ण पात्रों (घड़ों)में।
ताम्री — ताँबे से निर्मित।

तले	—	आधार में (घट के नीचे)।
पृथुच्छिद्रा	—	स्थूल छिद्र वाली।
द्युनिशनिमज्जनमित्या	—	एतत्पात्रस्य जलपूर्णपात्रेऽनवरत-जलागमने-नाहोरात्रे निमज्जनसंख्ययाऽहोरात्र प्रमाणम्, जलपूर्ण पात्र में निरन्तर जल का आयाम एक दिन व रात (60 घटी) में हो इस प्रमाण के द्वारा।
भक्तम्	—	विभाजितम्, विभाजित करके।
समतलमस्तकपरिधिः	—	तलं मूलम्। मस्तकमग्रम्। तयोः परिधी समौ यस्येत्येतादृशः। तल मूल को तथा मस्तक अग्रभाग को कहते हैं। इन दोनों की परिधि के समान।
भ्रमसिद्धो	—	समपरि (धि) वस्तुकरणं यन्त्रं लोके 'चरखा' इत्युच्यते, तत्संलग्नतया भ्रमेण तादृशः सिद्धो भवतीत्यर्थः।
दन्तिदन्तजः	—	हाथी के दाँत का।
चक्रांशांकम्	—	धातुमयं दारुमयं वा समं चक्रम्, धातु अथवा काष्ठ से निर्मित चक्र।
श्लथ शृङ्खलादिकाधारम्	–	शिथिल आधार (भ्रमण योग्य) बनाकर।
तन्मध्ये	—	(सुषिर) छिद्र युक्त आधार में।
सूक्ष्माक्षम्	—	सूक्ष्म रेखा गमनशील (चक्रभ्रमणावसर सुविधा के लिए) (लकड़ी देनी चाहिए, जिसे अक्ष से सम्बोधित करते हैं)
क्षिप्त्वा	—	डालकर।
अर्काभिमुखनेमिकम्	—	90 अंशों पर परिधि, सूर्याभिमुख परिधि।
तत्खार्धान्तश्च	—	वहाँ से क्षितिज गत चिन्ह तक
नतभागः	—	नतांश।
उन्नतलवः	—	उन्नतांश।

दलीकृतम् — (चक्र यंत्र को) आधा करने पर।
उशन्ति — वदन्ति, कहते हैं।
कोदण्डखण्डम् — कोदण्डस्य धनुषः खण्डमर्धे तुर्यगोलं, धनुष के खण्ड को।
दृङ्मण्डले — दृग्वृत्तानुकल्पचक्रादियंत्रम् , दृक् मण्डल में।
स्फुटकालः — सूक्ष्मकाल, अतिसूक्ष्म दिनगतकाल का प्रकार।

अभ्यासः

1. **संस्कृतभाषया उत्तराणि लिखत**
   - क) यन्त्राणां प्रयोजनं वर्ण्यताम्।
   - ख) गोलयन्त्रस्य निर्माणं कथं भवति?
   - ग) घटीमानम् किम्?
   - घ) दिग्देशकालानां ज्ञानं शङ्कुयन्त्रेण कथं जायते?
   - ङ) तुर्ययन्त्रं कथं भवति?
   - च) फलकयन्त्रवर्णनं सङ्क्षेपेण लिखत।
2. **अस्य पाठस्य पृष्ठभूमौ कः ग्रन्थः अस्ति, तमाश्रित्य संक्षिप्तं लेखं लिखत?**
3. **अस्य पाठस्य सारः स्वभाषया लेखनीयः।**
4. **सूक्ष्मकालग्रहणेन के लाभाः सन्ति?**
5. **स्पष्टीक्रियताम्**

   क्षितिजम्, नाडीवृत्तम्, स्फुटकालः, शङ्कुः, चक्रम्, लग्नम्।
6. **व्याख्यां कुरुत**
   - क) धीरेकं पारमार्थिकं यन्त्रम्।
   - ख) दिनगतकालावयवा ज्ञातुमशक्या विना यन्त्रैः।
   - ग) तच्छायातः प्रोक्तं ज्ञानं दिग्देशकालानाम्।
   - घ) सद्गोलयुक्तेर्गणितस्य सारं स्पष्टं प्रवक्ष्ये फलकाख्ययन्त्रम्।

दशमः पाठः

शुल्कव्यवहारः

प्रस्तुत पाठ कौटिल्यरचित **अर्थशास्त्र** के **शुल्कव्यवहार** प्रकरण से लिया गया है। कौटिल्य की अर्थनीति के प्रमुख तीन सिद्धांत हैं – पहले सिद्धांत के अंतर्गत ऐसे उद्योगों (Industries) को रखा गया है जिन पर राज्य का स्वामित्व हो और जो राज्य के द्वारा ही संचालित व संगठित हों। इन उद्योगों की पूँजी (Capital), श्रम (Labour), और प्रबंध (Management) का दायित्व राज्य पर ही निर्भर करे। दूसरे प्रकार के उद्योगों का संबंध जनता से है। द्वितीय सिद्धांत के अंतर्गत इस श्रेणी के उद्योग यथा कृषि, गो-पालन, वस्त्र-निर्माण आदि राज्य के नागरिकों की निजी संपत्ति (Private property) के रूप में माने गये। कौटिल्य की अर्थनीति का तीसरा सिद्धांत समाज में ऐसी सुव्यवस्था का निर्माण करना है जिसके अनुसार राज्य के समस्त उत्पादन (Production) वितरण (Distribution) और उपभोग (Consumption) पर शासनसत्ता का नियंत्रण बना रहे। इसीलिए राजा जनता पर कर लगाता था जिसे इस प्रस्तुत अंश में शुल्क की संज्ञा दी गयी है तथा आधुनिक वाणिज्य जगत् इसे Taxation कहता है। किस-किस मद (Item) पर कितना कर निर्धारित किया जाए, इसका वर्णन इस पाठ में है।

1. **शुल्कव्यवहारो बाह्यमाभ्यन्तरं चातिथ्यम्, निष्क्राम्यं, प्रवेश्यं च शुल्कम्।**
2. **प्रवेश्यानां मूल्यपञ्चभागः।**

3. पुष्पफलशाकमूलकन्दवल्लिक्यबीजशुष्कमत्स्यमांसानां षड्भागं गृह्णीयात्।
4. शङ्खवज्रमणिमुक्ताप्रवालहाराणां तज्जातपुरुषैः कारयेत्, कृतकर्मप्रमाणकालवेतनफल-निष्पत्तिभिः।
5. क्षौमदुकूलक्रिमितानकङ्कटहरितालमनःशिलाहिंगुलुकलोहवर्णधातूनां चन्दनागुरुकटुककिण्वावराणांसुरादन्ताजिनक्षौमदुकूलनिकरास्त-रणप्रावरणक्रिमिजातानामजैलकस्य च दशभागः, पञ्चदशभागो वा।
6. वस्त्रचतुष्पदद्विपदसूत्रकार्पासगन्धभैषज्यकाष्ठवेणुवल्कचर्ममृद्भाण्डानां धान्यस्नेहक्षारलवणमद्यपक्वान्नादीनां च विंशतिभागः पञ्चविंशतिभागो वा।
7. द्वारादेयं शुल्कपञ्चभागः आनुग्राहिकं वा यथादेशोपकारं स्थापयेत्।
8. जातिभूमिषु च पण्यानामविक्रयः।
9. खनिभ्यो धातुपण्यादाने षट्छतमत्ययः।
10. पुष्पफलवाटेभ्यः पुष्पफलादाने चतुष्पञ्चाशत्पणो दण्डः।
11. षण्डेभ्यः शाकमूलकन्दादाने पादोनं द्विपञ्चाशत्पणः।
12. क्षेत्रेभ्यः सर्वसस्यादाने त्रिपञ्चाशत्पणः, पणोऽध्यर्धपणश्च सीतात्ययः।

अतो नवपुराणानां देशजातिचरित्रतः।
पण्यानां स्थापयेच्छुल्कमत्ययं चापकारतः।।

शब्दार्थाः टिप्पण्यश्च

शुल्कव्यवहारः — शास्त्रानुसारशुल्कसङ्ग्रहः, शास्त्र द्वारा निर्दिष्ट शुल्क (कर-वसूली करना) इकट्ठा करना।

बाह्यमाभ्यन्तरम् — बाह्य-अपने राज्य में उत्पन्न वस्तुओं पर चुंगी आभ्यन्तर-राजमहल तथा राजधानी के भीतर उत्पन्न होने वाली वस्तुओं की चुंगी।

आतिथ्यम् — विदेश से आने वाले माल पर चुंगी।
निष्काम्यम् — बाहर जाने वाला माल (निर्यात का सामान)।
प्रवेश्यम् — बाहर से आने वाला माल (आयात का सामान)।
वल्लिक्यबीज — धान्य।
शुष्कमत्स्य — सूखी मछली।
गृह्णीयात् — ग्रहण की जानी चाहिए।
वज्र — हीरा।
तज्जातपुरुषैः — उन-उन (यथा मणि, मुक्ता, प्रवाल आदि) विशेषज्ञों के द्वारा।
क्षौमदुकूलं — मोटा व महीन रेशमी कपड़ा।
अगरु — अगर नाम का सुगन्धित द्रव्य।
कटुककिण्वावराणाम् — कड़वे और मादक बीजों से निकाला गया द्रव्य।
दन्त — हाथीदाँत
अजिन — मृगचर्म
आस्तरण — बिछौना
प्रावरण — ओढना
कार्पास — कपास
भैषज्य — औषधि या दवाई।
वेणु — बाँस
वल्क — छाल
मृद्भाण्डानाम् — मिट्टी के बरतनों का।
स्नेह — घी और तेल
क्षारलवण — खारा नमक

द्वारादेयम् — द्वारपाल को चाहिए।
आनुग्राहिकम् — नगर के प्रधान द्वार से प्रविष्ट होने वाली (वस्तुयें)।
जातिभूमिषु — जिन प्रदेशों में जो चीजें पैदा होती हैं, उन पर।
अविक्रय — न बेचने योग्य।
खनिभ्यो — खानों से तैयार हुआ।
पण — उस समय चलने वाली मुद्रा का नाम।
क्षेत्रेभ्यः — खेतों से।
सस्य — अनाज।

अभ्यासः

1. **संस्कृतभाषया उत्तराणि दीयन्ताम्**
   क) शुल्कव्यवहारस्य के प्रकाराः आसन्?
   ख) मूल्यपञ्चभागः अस्याभिप्रायः कः?
   ग) पुष्पफलशाकमूलकन्देषु शुल्कस्य निर्धारणं कथम् भवति स्म?
   घ) मृद्भाण्डोपरि शुल्कस्य सीमा का?
   ङ) पुष्पफलवाटेभ्यः पुष्पफलादाने कति पणाः दण्डः?
2. **व्याख्येयः**
   अतो नवपुराणानां देशजातिचरित्रतः।
   पण्यानां स्थापयेच्छुल्कमत्ययं चापकारतः।।
3. **शुल्कव्यवहारस्य किं प्रयोजनम्?**
4. **अस्य पाठस्य सारं हिन्दीभाषया स्पष्टीकुरुत?**
5. **टिप्पण्यः लिख्यन्ताम्**
   आतिथ्यम्, निष्क्राम्यम्, प्रवेश्यानाम्, आनुग्राहिकम्, पञ्चविंशतिभागः, सस्यम्।

एकादशः पाठः

व्यावसायिकपत्रव्यवहारः

प्रस्तुत पाठ **कौटिल्य** के **अर्थशास्त्र** के **शासनाधिकार** से लिया गया है। राजा की आज्ञा का नाम शासन है। जो कुछ भी राजा कहे, उसे लिखकर ही पहुँचाया जाता है, इसलिए किस प्रकार पत्र लिखा जाए, उसमें क्या आवश्यक गुण हों, कौन-सा लिखा गया पत्र श्रेष्ठ कोटि में आता है तथा पत्र लिखने में किस प्रकार दोषों से सावधान रहा जाए, इसका वर्णन प्रस्तुत अंश में है। वाणिज्य प्रबंधन (Business Administration) में दक्षता हेतु यह महत्त्वपूर्ण है।

1. **शासने शासनमित्याचक्षते। शासनप्रधाना हि राजानः, तन्मूलत्वात् सन्धिविग्रहयोः।**
2. **तस्मादमात्यसम्पदोपेतः सर्वसमयविदाशुग्रन्थश्चार्वक्षसे लेखवाचनसमर्थो लेखकः स्यात्। सोऽव्यग्रमना राज्ञःसन्देशं श्रुत्वा निश्चितार्थं लेखं विदध्यात्, देशैश्वर्यवंशनामधेयोपचारमीश्वरस्य, देशनामधेयोपचारमनीश्वरस्य।**
3. **अर्थक्रमः, सम्बन्धः, परिपूर्णता, माधुर्यमौदार्यं, स्पष्टत्वमिति लेखसम्पत्।**
4. **तत्र यथावदनुपूर्वक्रिया प्रधानस्यार्थस्य पूर्वमभिनिवेश इत्यर्थस्य क्रमः।**
5. **प्रस्तुतस्यार्थस्यानुपरोधादुत्तरस्य विधानमासमाप्तेरिति सम्बन्धः।**

6. अर्थपदाक्षराणामन्यूनातिरिक्तताहेतूदाहरणदृष्टान्तैरर्थोपवर्ण-
   नाश्रान्तपदतेति परिपूर्णता।

7. सुखोपनीतचार्वर्थशब्दाभिधानं माधुर्यम्।

8. अग्राम्यशब्दाभिधानमौदार्यम्।

9. प्रतीतशब्दप्रयोगः स्पष्टत्वमिति।

10. निन्दा प्रशंसा पृच्छा च तथाख्यानमथार्थना।
    प्रत्याख्यानमुपालम्भः प्रतिषेधोऽथ चोदना।।
    सान्त्वमभ्यवपत्तिश्च भर्त्सनानुनयौ तथा।
    एतेष्वर्थाः प्रवर्तन्ते त्रयोदशसु लेखजाः।।

11. तत्राभिजनशरीरकर्मणां दोषवचनं निन्दा। गुणवचनमेतेषामेव प्रशंसा। कथमेतदिति पृच्छा। एवम् इत्याख्यानम्। देहीत्यर्थना। न प्रयच्छामीति प्रत्याख्यानम्। अननुरूपं भवत इत्युपालम्भः। मा कार्षीः इति प्रतिषेधः। इदं क्रियतामिति चोदना। योऽहं स भवान्, मम यद् द्रव्यं तद्भवतः इत्युपग्रहः सान्त्वम्। व्यसनसाहाय्यमभ्यवपत्तिः। सदोषमायतिप्रदर्शनमभिभर्त्सनम्।

12. अनुनयस्त्रिविधोऽर्थकृतावतिक्रमे पुरुषादिव्यसने चेति।

13. अकान्तिर्व्याघातः पुनरुक्तमपशब्दः संप्लवः इति लेखदोषाः।

14. तत्र कालपत्रकमचारुविषमविरागाक्षरत्वमकान्तिः।

15. पूर्वेण पश्चिमस्यानुपपत्तिर्व्याघातः।

16. उक्तस्याविशेषेण द्वितीयमुच्चारणं पुनरुक्तम्।

17. *लिंगवचनकालकारकाणामन्यथाप्रयोगोऽपशब्दः।*

18. अवर्गे वर्गकरणं वर्गे चावर्गक्रिया गुणविपर्यासः संप्लव इति।

19. सर्वशास्त्राण्यनुक्रम्य प्रयोगमुपलभ्य च।
    कौटिल्येन नरेन्द्रार्थे शासनस्य विधिः कृतः।।

शब्दार्थाः टिप्पण्यश्च

शासनम्	—	शासने शासनमिति, राजा की ओर से लिखित आज्ञा या प्रतिज्ञा का नाम शासन है।
तन्मूलत्वात्	—	तेषां मूलत्वात् (राजा लोग) उनकी (लिखी बातों के ही), मूल में होने के कारण।
सन्धिविग्रहयोः	—	सन्धिश्च विग्रहश्च सन्धिविग्रहौ इति तयोः, दो राजाओं का परस्पर किसी बात पर समझौता संधि है, उसके विपरीत विग्रह है।
अमात्यसम्पदोपेतः	—	अमात्य (मन्त्री - जो मंत्रणा दे) की योग्यताओं वाला।
सर्वसमयविद्	—	सब समयों (आचार व व्यवहार) को जानने वाला।
आशु ग्रन्थ	—	शीघ्र ही वाक्य योजना (ग्रंथ) करने में निपुण।
अव्यग्रमनाः	—	व्यग्रं मनः यस्य सः, व्यग्रमना,न व्यग्रमना इति अव्यग्रमना, प्रकृतिस्थ (हर्षशोकादि दोषों से परे) मन वाला।
निश्चितार्थम्	—	स्पष्ट अभिप्राय प्रकट करने वाला (लेख)।
विदध्यात्	—	कुर्यात्, करना चाहिए।
देशैश्वर्यवंशनामधेयो	—	(लेख यदि किसी राजा से संबद्ध हो) राजा का, (तब)
उपचारमीश्वरस्य	—	देश, ऐश्वर्य, वंश व नाम का स्पष्ट उल्लेख (होना चाहिए)।
श्रुतानि	—	योग्यता।

ऋद्धि — धन-संपत्ति।

यौनानुबन्धम् — वैवाहिक संबंध।

समीक्ष्य — अवेक्ष्य, देखकर।

पुरुषानुरूपम् — प्राप्तकर्ता (लेख या पत्र प्राप्त करने वाला), पुरुष के अनुरूप।

अनुपरोधाद् — बाधक न होने पर।

अर्थपदाक्षराणामन्यूनातिरिक्तता — अर्थपद व अक्षरों का न्यूनाधिक्य न होना।

अर्थोपवर्णनाश्रान्तपदता — (दृष्टांत सहित) अर्थ का निरूपण करना और प्रभावहीन शब्दों का प्रयोग न करना।

सुखोपनीतचार्वर्थशब्दाभिधानम् — सुखपूर्वक लाया गया अर्थात् सरल,व सुबोध शब्द का प्रयोग।

अग्राम्य — शिष्ट (शिष्ट शब्दों का प्रयोग करना)।

प्रगीतशब्दप्रयोगः — सुप्रसिद्ध शब्दों का प्रयोग करना।

एतेष्वर्थाः — इन प्रयोजनों में।

प्रवर्तन्ते — प्रकट किया जाता है।

तत्राभिजनशरीरकर्मणाम् — वहाँ (उस लेख में),किसी के वंश, शरीर व कार्य में।

दोषवचनम् — दोषारोपण

कथमेतदिति — यह कैसे हुआ।

एवम् — इसको इस प्रकार कहना चाहिए।

देहि — दीजिए

अननुरूपं भवतः — यह कार्य आपने अपने अनुरूप नहीं किया।

मा कार्षीः	—	ऐसा मत करो।
व्यसनसाहाय्यम्	—	आपत्ति के समय सहायता करना।
सदोषमायतिप्रदर्शनम्	—	दोष दिखाकर धमकी देना।
अनुनयस्त्रिविधः	—	अनुनय तीन प्रकार का होता है – 1.अर्थकरणनिमित्तक, किसी आवश्यक कार्य को करने के लिए अनुनय किया जाना, 2. अतिक्रमनिमित्तक – किसी कुपित पुरुष को शांत करने के लिए अनुनय करना 3. पुरुषाधिव्यसननिमित्तक – किसी आत्मीय की मृत्यु के कारण आयी हुई विपत्ति में अनुनय करना।
लेखदोषाः	—	पत्र लेख के दोष।
कालपत्रकम्	—	मलिन कागज पर लिखना या स्याही पड़े कागज पर लिखना।
अचारु	—	भद्दे अक्षर (लिखना)।
विषम	—	छोटे बड़े (अक्षर लिखना)।
विरागाक्षर	—	फीकी स्याही से लिखना।
पूर्वेण	—	पहले (लिखे गये लेख) के द्वारा।
पश्चिमस्यानुपपत्तिः	—	बाद में (लिखे लेख का)विरोध हो जाना।
अन्यथाप्रयोगः	—	विपरीत प्रयोग।
वर्गकरणम्	—	विरामादि चिन्हों की व्यवस्था।
गुणविपर्यासः	—	अर्थक्रम के अनुसार योजना न करना।
अनुक्रम्य	—	विधिवत् अध्ययन करके।
प्रयोगमुपलभ्य	—	प्रयोगों की अच्छी तरह परीक्षा करके।

अभ्यासः

1. संस्कृतभाषया उत्तराणि दीयन्ताम्

क) शासनस्य कः अभिप्रायः?

ख) कः लेखकः पत्रलेखने सफलः?

ग) कानि तत्त्वानि समीक्ष्य लेखं विदध्यात्?

घ) के षड्गुणाः लेखसम्पदो भवन्ति?

ङ) लेखप्रयोजनानि कानि?

च) के भवन्ति लेखदोषाः?

2. रिक्तस्थानानाम् पूर्त्तिः क्रियताम्

क) .... प्रधाना हि राजानः।

ख) .... शब्दाभिधानमौदार्यम्।

ग) तत्राभिजनशरीरकर्मणां .... निन्दा।

घ) इदं क्रियतामिति ....।

ङ) मा कार्षीः इति ....।

3. व्याख्यायेताम्

क) अकान्तिर्व्याघातः पुनरुक्तमपशब्दः संप्लवः इति लेखदोषाः।

ख) शासनस्य विधिः।

4. स्पष्टीक्रियन्ताम्

अर्थक्रमः, परिपूर्णता, उपालम्भः, माधुर्यम्, पृच्छा।

5. अस्य पाठस्य उद्देश्यम् स्पष्टीक्रियताम्।

6. अस्य पाठस्य पृष्ठभूमौ कः ग्रन्थः अस्ति?

the rest of it to "see how it comes out." While the quality of the reading should not be neglected, the emphasis should be on the rate of reading. In order that this may be done, the reading material must be simple.

2. **Emphasizing rate of silent reading by informal testing.** One reason why pupils read slowly is that the teacher pays no attention to the rate of silent reading. In Chapter I we pointed out that one defect in our ordinary measurement of results was the neglect of the rate of work. The rate of reading is an important "dimension" of the ability to read silently. In many cases a teacher can increase the rate of his pupils' reading by simply recognizing it as one "dimension" of the ability to read. This can be done by asking the pupils to read silently beginning with a certain paragraph in their text (school reader, geography, history, or elementary science). At the end of a suitable period, three to five minutes, stop them and have them count the number of lines read. This number will be a crude measure of the rate of reading. This should be a part of the regular instruction in silent reading. If the teacher doubts the quality of the reading, it can be tested informally by having the pupils answer a set of questions based upon the lines read.

In the survey of the Cleveland Public Schools an informal silent reading test was given by having the pupils read silently in the Jones Readers. After some preliminary testing to give the pupils an understanding of what they were to do, the teacher read aloud a page to the class, the pupils having their books open. When he came to the turning of the page the teacher stopped reading and noted the time. The pupils continued the reading silently. At the end of *one* minute they were stopped and the number of lines read were counted. The pages used for the test and the average number of lines read are given in Table XI. In interpreting the average number of lines given in this table, one must remem-

ber that the material read in the upper grades was more difficult and that the lines contained more words. He may use these facts as tentative standards for judging his pupils when testing their rate of reading in the way suggested.

TABLE XI.* SHOWING RATE OF SILENT READING IN INFORMAL TESTING

Grade	*Book*	*Preliminary page*	*Test pages*	*Average number of lines read — 41 schools*
2A	II	101	102-103	16
3A	III	97	98-99	22
4A	IV	61	62-63	21
5A	V	47	48-49	20
6A	VI	63	64-66	24
7A	VII	63	64-66	21
8A	VIII	247	248-249	21

* Judd, C. H., "Measuring the Work of the Public Schools," *Cleveland Education Survey*, p. 201.

Rapid readers good readers. It has commonly been thought that a thorough understanding required that the pupil should read slowly and carefully, and that the rapid reader understood very little of what he read. It is, of course, true that the pupil who reads with extreme rapidity, or "skims" over the page, does not comprehend completely what he reads, but we now have evidence which shows that in many cases a rapid reader is a "good" reader and a slow reader is a "poor" reader.

Fig. 12 is reproduced from the *Report of the Cleveland Survey* to show the relation which was found to exist between rate and quality of silent reading as measured by Gray's Silent Reading Tests.[1] On the basis of their scores 1831 pupils were divided into the nine groups indicated in the figure.

[1] These tests are not described in this book because they are not suited to general classroom use. For a complete description of them the reader is referred to Gray, William S., *Studies in Elementary School Reading Through Standardized Tests.* (Supplementary Educational Monographs, University of Chicago Press.)

The per cent of the pupils in each group is given by the number inside of the circle. The size of the circle represents the size of the group. The figure shows very clearly that

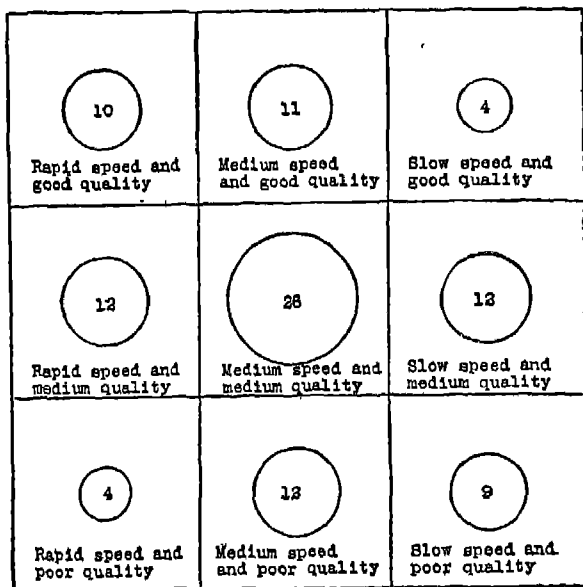



Fig. 12. Per cent of 1831 Cleveland Pupils found in each on Nine Speed and Quality Groups in Silent Reading. (*From Judd's "Measuring the Work of the Public Schools."*)

a rapid reader is good in quality more frequently than he is poor in quality and the opposite is true for slow readers. The application of this fact is that in many cases pupils will improve in quality of reading when they increase their rate. Teachers should not expect to secure a higher degree of comprehension by urging their pupils to read more slowly.

3. **More opportunity for silent reading.** Practice in reading is even more necessary for producing the ability to read

rapidly than for engendering the ability to comprehend. The suggestions on page 64 apply here also. It is particularly important that the material should not be difficult to understand.

4. **Less emphasis upon oral reading in the intermediate and grammar grades.** Oral reading is necessary in the primary grades, but as the pupil progresses from grade to grade, more emphasis should be placed upon silent reading and less upon oral reading. From about the fourth grade silent reading should receive the greater emphasis. Failure to do this frequently causes the pupil to acquire habits which make rapid silent reading impossible. Two cases of slow readers due to this cause are described on pages 73 and 84.

Summary for Type II. Under this type we have considered the case of a class which reads too slowly. The following causes were considered: (1) attempt to secure a high degree of comprehension by urging the pupils to read more slowly; (2) over-emphasis upon oral reading; (3) failure of teacher to recognize the rate as important. For increasing the rate of silent reading the following correctives were given: (1) motivation; (2) greater emphasis upon the rate of reading; (3) more opportunity for silent reading; and (4) less emphasis upon oral reading.

Type III. Scores too widely distributed. In Fig. 13 we show the scores of a fifth-grade class whose median scores are approximately standard. (The test was given February 4, and hence it is not to be expected that the class had attained the seventh-grade May standard.) The noticeable thing about this record is that the scores for rate range from one score between 31 and 35 to one above 130, and for comprehension from one score between 1 and 2.9 to one between 35 to 39.9. Thus, there are in this fifth-grade class some pupils below third-grade standards (60, 9.0) and others

Rate Score		Comprehension Score	
Interval	Number of Pupils	Interval	Number of Pupils
Above 130	1		
126 to 130	1		
121 to 125			
116 to 120	2		
111 to 115		80 & above	
106 to 110	4	70 to 79.9	
101 to 105		60 to 69.9	
96 to 100	1	50 to 59.9	
91 to 95		45 to 49.9	
86 to 90	2	40 to 44.9	
81 to 85		35 to 39.9	1
76 to 80		30 to 34.9	2
71 to 75		27 to 29.9	2
66 to 70	1	24 to 26.9	1
61 to 65		21 to 23.9	4
56 to 60	2	18 to 20.9	
51 to 55	1	15 to 17.9	
46 to 50		13 to 14.9	
41 to 45	2	11 to 12.9	1
36 to 40		9 to 10.9	1
31 to 35	1	7 to 8.9	1
26 to 30		5 to 6.9	4
21 to 25		4 to 4.9	
16 to 20		3 to 3.9	
11 to 15		2 to 2.9	1
6 to 10		1 to 1.9	
0 to 5		0 to .9	
Total	18	Total	18
Median	93	Median	21.8

FIG. 13. SHOWING THE SCORES OF A FIFTH-GRADE CLASS ON MONROE'S STANDARDIZED SILENT READING TESTS. (*Type III.*)

above the eighth grade[1] standards (108, 27.5). The teacher's particular problem in this case is with the pupils who have the low scores. Those who are above standard do not constitute a problem, if they are above in both rate and comprehension, except that the teacher should consider whether these pupils could spend the time now devoted to reading more profitably on some other subject. It might happen, for example, that some of these pupils might be below standard in arithmetic, spelling, or

[1] Accurate comparison of fifth-grade scores with eighth-grade standards is not possible because different tests are used in these grades. However, the statement is probably true.

language. If so they need to devote some extra time to these subjects.

The condition shown in Fig. 13 may be due to an unwise classification of the pupils and some adjustments should be made which would reduce the wide range of scores. However, this would probably reduce the number of cases only slightly and the problem would still remain.

Uniformity in instruction for all the members of a class widens variability among them, making the weak ones relatively weaker and the strong ones relatively stronger. To prevent this widening of the variability more attention must be given to individual instruction. This does not mean a leveling of all members of a class, but rather affording a maximum of opportunity to each member to do those things most needful to him. Those things which he can already do well he should not be required to do, even though some other members of the class need to do them.

Those children falling far below the median of the class should be given special physical examination to discover if possible the cause. Sometimes eyesight is found to be poor. Frequently some other physical defect has prevented normal mental growth. Sometimes an examination by means of approved intelligence tests, such as the Binet-Simon tests,[1] reveals that the child is mentally incapable of doing work of the regular school type.

Illustrations of individual defects. It may be that the pupil needs to be *taught how to read silently.* Not very much attention is given to teaching pupils how to read silently. The instruction in reading is confined largely to oral reading. A pupil who has not learned how to read silently needs instruction. One teacher writes of a certain pupil as follows:

[1] See especially Terman, L. M., *The Measurement of Intelligence* (Houghton Mifflin Company, Boston, 1916). A simple guide for the use of the intelligence scale.

From the tests given and from her work in English which I have had for two years, I find that she has only a vague hazy kind of meaning for many of the words needed for seventh-grade work. She does not see words in their relation to others in the sentence. When she finds a name for a combination of letters she is satisfied, thinking that she is reading. She has failed this year. I hope this may rouse her to the effort of which I am sure she is capable. If I can only make her see that reading means more than *naming* words and persuade her to work, I am sure she can overcome her difficulties.

Another difficulty may be vocabulary. A boy who made a low score on the silent reading test was given the vocabulary test, on which he made a very low score. His teacher describes him as follows:

His greatest difficulty seems to be a lack of vocabulary. He memorizes history instead of studying for the thought. Lately, he has gotten away from this to some extent and begins to sum up the thought rather than repeat words when called upon. He still (after some individual instruction) finds so many unfamiliar words in any new paragraph that his progress is very slow, but he attacks his problem with more intelligence than he showed at first.

How to bring individual pupils up to standard. If the child is nearly normal physically and mentally, but has not developed ability to get meaning from printed language, he presents a problem in instruction calling for the best professional skill to solve. In dealing with such pupils the suggestion given for Types I and II can be used. Giving the pupil a strong motive frequently will solve the problem.

It is quite certain that a pupil far below the median in this basic ability has never made use of printed language to secure help in satisfying his own childish desires. If possible, situations must be brought about in which his desires or plans depend for their fulfillment upon his reading. It may be, for example, that his mother or father has been in the habit of reading stories to him. If so, and he can be made to

be keenly interested in a story by having a part of it read to him, he should have to read the rest himself to satisfy his desire to know the rest of the story. Possibly he would like to be the leader in an occasional nature-study excursion, but, of course, it will be expected that he look up information concerning the things they see on the trip and be able to report later to the group. That is the business of the leader. Or he might umpire the baseball game if he made sure of the rules; or assign the parts in the coming school entertainment, if he read the various parts carefully so as to be able to make a wise assignment; or score the class compositions on the basis of which was most interesting. Such a list of possible opportunities for calling into service a child's silent reading ability might be largely extended. The two things to guard against are (1) making reading a punishment and (2) confusing child need with school need. The thing to be accomplished is to give the child a chance to do something which he really wishes to do, but cannot do without reading.

The case of a slow and inefficient reader. Judd[1] gives the case of a girl in the fifth grade who was average or above in all her school subjects except reading. In this one subject she had been rated as a poor student from the first through the fourth grade. Her health was good and she had been regular in her attendance at school. With respect to reading she is described as follows:

> Reading seems to be her greatest weakness. Her fourth-grade teacher reported her as "a slow reader who reads hesitatingly and haltingly, repeating words and phrases. Her breathing is very shallow, often causing her to pause for breath in the middle of a word or phrase. Her voice is thick, heavy, and unpleasantly nasal.

[1] Judd, C. H., *Reading: Its Nature and Development.* Supplementary Educational Monographs (University of Chicago Press), vol. 2, no. 4, p. 82. (The paragraph headings in this and the other quotations from this monograph have been inserted by the author.)

Silent reading is particularly distasteful to her. She always settles down to it reluctantly and tardily."

From the home comes much the same story: "She has never read a story to herself, though she has several attractively illustrated children's books. She frequently, however, after eagerly studying the illustrations in a new book, begs to have the story read to her, saying, 'You read it, mother. I can't understand it very well when I read it myself.'"

This pupil was carefully tested in both oral and silent reading. In oral reading her score was 33, while the standard is 48. She made many errors, particularly mispronunciations. In silent reading, she read even more slowly than she did orally.

Observations made during the silent-reading tests showed that there was much vocalization. The reading was done in a low whisper, and difficult words, as stated above, were spelled out letter by letter. She followed the line with her finger. In one of the early practice periods, when urged to read more rapidly, she remonstrated, saying that she could not hear the words so well if she did.[1]

The correctives which were used. From the foregoing data it is evident that her difficulties in reading were due to a lack of familiarity with printed words and a lack of method of working out new or unknown word-forms. In an effort to help her overcome this handicap she was given various types of training during eighteen weeks. The first six weeks were devoted to a great deal of oral reading. The second six weeks were spent on drills in phonics and in word analysis. During the last six weeks she was given a great deal of silent reading. While each period of six weeks thus stressed some one phase of reading, all three types of work were carried along throughout the eighteen weeks. For example, oral reading was continued with less emphasis during the last twelve weeks.

The selections for oral reading were made along the line of the pupil's school interests in history and geography. These included Baldwin's *Fifty Famous Stories* and *Thirty More Famous Stories*, Harding's *Story of Europe*, Allen's *Industrial Europe*, Carpenter's *Eu-*

[1] This is the case of a pupil whose defect was probably caused by overemphasis upon oral reading. The pupil had never been taught to read silently. (*Author.*)

rope, "Our European Cousins Series," the Merrill and the Horace Mann *Third* and *Fourth Readers*, Tappan's *Old World Heroes*, Terry's *The New Liberty*, and Brown's *English History Stories*.

Phonics and word analysis were emphasized during the second six weeks. Various systems of phonics with some modifications to suit the particular needs were used. Words mispronounced in oral-reading lessons were worked out phonetically, and lists of words similarly pronounced were built up and reviewed from time to time. There seemed to be a gradual growth in ability to attack an unfamiliar word. In the earlier period the pupil frequently looked at the word helplessly or pronounced a known syllable, but was unable to attack it at all phonetically. She usually asked the instructor to pronounce it. Later she began immediately to sound the new word phonetically, and though sometimes making a mistake in the length of the vowel or in the position of the accent, her manner of attack indicated that she had confidence in her own ability to work it out.

Silent reading was emphasized during the last six weeks after some training in silent reading had been given throughout the first twelve weeks. For special training paragraphs or selections dealing with topics of particular interest to the pupil were used. In many instances the original selections were edited, and the words which had been used in the phonic exercises were woven into the text. Frequently before the silent reading began a question was raised, the answer to which was to be found in the text. Oral or written reproduction or a discussion of the thought of the selection usually followed the reading. It is interesting to note, in passing, that though no effort was made to reduce the vocalization so perceptible at first, it entirely disappeared except when an unusually difficult passage was encountered.

The result. One of the significant results is that mentioned in the closing sentence of the above paragraph. The pupil had learned how to read silently without pronouncing the words in a whisper. After the correctives described above had been used, the pupil was tested again in both oral and silent reading. She showed a decided gain in rate of oral reading and a reduction in the number of errors. In silent reading her rate had increased so that she now read more

rapidly silently than orally, whereas before this special training the opposite was true. At the same time she made large gains in comprehension.

Her teachers report that Case G [the pupil described above] reads with much greater ease and fluency of expression. The quality of her voice has improved and the nasal tones have almost disappeared. She seems to enjoy reading silently much more than before training. Frequently she expresses a preference for reading a passage silently, saying, "I can do it faster."

The case of a pupil deficient in vocabulary. A seventh-grade boy is described by Judd,[1] whose most striking defect in reading was a lack of word meaning. He is described as follows:

In general school standing he is rated as a poor student, although he is given a grade of good (B) in the manual arts, music, and physical training. In all other subjects he is poor. During the past two and a half years he has received no grade higher than C in history, geography, science, literature, composition, and grammar. In this connection it is interesting to note that progress in these subjects after the fourth grade is dependent to a large degree on ability to get thought from the printed page.

His teachers report him as a shy, timid boy, easily embarrassed, lacking in self-confidence and initiative in the classroom, though very energetic and responsive on the athletic field. He rarely takes part voluntarily in class discussions, and when called on to do so responds in a few brief, fragmentary sentences, badly expressed, but usually containing a thought or an idea on the topic being considered. His English teacher finds great difficulty in getting him to read with any degree of expression, for he makes no attempt to group words into thought units. He reads in a dull, monotonous tone, slurring words and phrases. When asked to tell what he has read, he reproduces a few ideas in short, scrappy sentences, for apparently he makes few associations as he reads. His teachers in history and geography explain his poor standing in their subjects as attributable to an inability to get ideas from the text. He apparently reads as rapidly silently as any in the class, but gets and retains less of the thought.

[1] Judd, C. H., *Reading: Its Nature and Development.* Supplementary Educational Monographs (University of Chicago Press), vol. 2, no 4, p. 106

The tests in oral and silent reading sustained the opinions given by his teachers. In the oral test he read fairly rapidly, pronouncing the words mechanically and enunciating poorly. . . .

The test in silent reading defined more clearly his apparent difficulties. . . . Clearly this particular seventh-grade boy ranks in comprehension at a lower level than the poorest readers in the two preceding grades. This result verifies the estimates of his teachers of history and geography.

A résumé of the facts brought out by the tests would seem to indicate that he has acquired a mastery of the rudimentary mechanics of word recognition, but lagged far behind in the mastery of word meaning. He read words as mere names and not as symbols of ideas.

The correctives which were used. How to build up a background of meaning that would form a basis for his reading was and still is an urgent and difficult problem. Because of his interest in animal stories and tales of camp and pioneer life, emphasis was laid throughout the eighteen weeks on literature dealing with these topics. *The Boy Scouts' Manual*, Custer's *Boots and Saddles*, Roosevelt's *Winning of the West*, Southworth's *Builders of Our Country*, Book II, the Merrill and the Horace Mann *Fourth* and *Fifth Readers*, Muir's *Stickeen*, Coffin's *Boys of '76*, the Seton Thompson and Kipling stories, and similar literature were drawn upon freely. Silent reading was continued throughout the eighteen weeks, but was especially emphasized during the first six weeks and again during the last six weeks. After reading a selection the pupil reproduced it orally or in writing. These reproductions at first were so meager and inadequate that he frequently had to re-read several items before he could answer the questions raised. Many selections were read in this way paragraph by paragraph, and the main points jotted down to assist in the organization of the thought.

Before the work had progressed very far it became apparent that definite word-study was necessary in order to build up a background of meaning. Words were studied in the context for meaning, and certain ones were chosen for detailed analysis of prefix, suffix, and stem. A stem-word analyzed in this manner became the nucleus for grouping together other closely related words more or less familiar to the student. The word "traction," encountered in an article on the "Lincoln Highway," brought out a discussion of traction engines, their use in plowing, road-building, and trench warfare, why so called, etc. This centered attention upon the stem

"tract." As its meaning became clear the following list was elaborated:

subtract	distract	attraction
contract	extract	distraction
detract	retract	subtraction
attract	contraction	extraction

A study of the prefixes in these words gave a point of leverage for attacking the meaning of words containing them. In this type of prefix study only those words were listed whose stems were familiar to the pupil; as, for example:

recall	rebound	retake
reclaim	retain	reinforce
rearrange	reform	return
regain	remake	reframe, etc.

In a similar manner an acquaintance was made with the most common suffixes.

The meaning of some words was approached by the study of synonyms and equivalent idiomatic phrases. These were, as far as possible, studied in the context and discussed at length to bring out shades of difference in meaning. "An indomitable hero," met in the pioneer tales, brought forth the following synonyms and idiomatic phrases:

indomitable	fearless	stout-hearted
brave	heroic	intrepid
courageous	bold	audacious
resolute	daring	defiant
manly	plucky	undismayed

to look danger in the face
to screw one's courage to the sticking-point
to take the bull by the horns
to beard the lion in his den
to put on a bold front

This type of intensive word-study was continued throughout the first six weeks, but was supplemented by incidental word-study during the remaining twelve weeks.

Oral reading was given special attention during the second six weeks and continued during the following six weeks. The literature

was of the same general type as that used in silent reading. The purpose was to improve, if possible, enunciation and expression. Special drills in the enunciation of vowels and of the terminal and initial consonants were a part of each reading lesson. Many of these drills were taken from reading books. Selections were studied silently before being read aloud and the meaning discussed. The various thought units were marked off and the whole selection was then read aloud. Before the close of each lesson the pupil read a selection at sight, unaided by this kind of preparation.

The result. A test in oral reading after this special training showed a reduction of fifty per cent in the number of errors and a gain in rate of reading. In silent reading a greater gain was made, especially in comprehension.

An illustration of group and individual instruction. A fourth-grade teacher [1] has written of her experience in teaching reading to a class of twenty pupils by group and individual instruction based upon the results of testing. Her report is so suggestive that we quote at some length:

In October pupils were tested to ascertain the oral- and silent-reading rate of each individual. Five oral and five silent trials were made, and the averages obtained and used as measures of reading rate. . . . With but one exception the rapid readers made fewer mistakes. Comprehension was tested informally. Rapidity and comprehension seemed to go together. Intensive instruction was given. Especial attention was paid to poor readers. After two weeks there was no improvement in the rate of the three poorest readers. The only noticeable improvement was made by the better readers. It was evident that the least capable were getting the least from instruction, though receiving more attention. This presented a problem . . . .

Ten types of instruction were planned to cover as many individual needs. The class *Reader* was supplemented by a carefully selected list of books for extensive reading. Methods were devised whereby maximum effort would be called forth and interest sustained. Rate was found to be a measure of improvement which the

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[1] Zirbes, Laura, "Diagnostic Measurement as a Basis for Procedure"; in *Elementary School Journal* (March, 1918), vol. 18, pp. 505–22.

children could comprehend. They were, therefore, made aware of their rate of reading and kept graphic records of their individual standings in monthly regrouping tests. "A" readers were those whose rate was more than thirteen lines per minute. They were given the privilege of selecting their own material from the supplementary bookshelf for silent reading. This shelf was called "Story Row." The books were arranged in groups according to content. A regular library system was used so that the teacher could ascertain at any time what each child was reading and what he had finished. The quality of the silent reading could thus be revealed by conversation with the pupil. Children who had enjoyed a book were asked to review it for others who might care to read it. Favorite chapters were illustrated. Some children chose informational material. They would recount interesting things which they had learned from their reading, and create a great demand for the book which they had read. No more than two books could be used by a pupil at one time and stories had to be finished before another story book could be begun.

"B" readers were those whose rate was more than nine lines per minute, but not more than thirteen. Pamphlets were provided for their supplementary reading. The material was easier and the content quite suited to their comprehension. Otherwise the system used for the "B" readers was like that for the "A" groups. They had less time for supplementary reading as they required more intensive work with the teacher. Their pamphlets were very popular and were often read by "A" readers.

There was also a group called "C" readers whose rate was between six and nine lines per minute, and another group of "D" readers who read even more slowly and got practically no meaning from the subject-matter. Their supplementary material consisted of separate stories. These they read with the teacher, alternating with her. They liked to have stories read to them. The teacher used her book. The group looked over her shoulder and kept the place, picking up the story and reading on when she stopped, until the end of a paragraph was reached. The meaning was then discussed and the reading continued.

Each child in the class subscribed to a little nature magazine which was kept in the desks for reading during odd minutes. Several other magazines, an atlas, and a file containing good original stories by the children were also at their disposal for this purpose.

The regular reading instruction was the visible means by the

aid of which each pupil hoped to get into a group higher than his own by the next measurement.

These groupings were based on rate and were not identical with those made for corrective teaching. The procedures just described, together with the intensive teaching in type lessons which follow, were jointly responsible for improvements in reading rate and quality. This report would, therefore, be incomplete if detailed descriptions of methods used to secure the interest of the individual child were omitted. [Seven of the type lessons relate to oral reading. They are omitted.]

Type lesson 3. Silent reading for the purpose of oral reproduction and comprehension.

Type lesson 4. Silent reading in search of a given phrase, answer, idea, or suggestion in the content of supplementary books, geography text, arithmetic text, and blackboard work.

Type lesson 10. Word-study, with difficult words, for ready recognition, pronunciation, and comprehension. Word-building and word-structure studied.

Results. Fig. 14 shows the results for November, December, and February in silent reading. The range of scores has not been reduced. In fact it has been
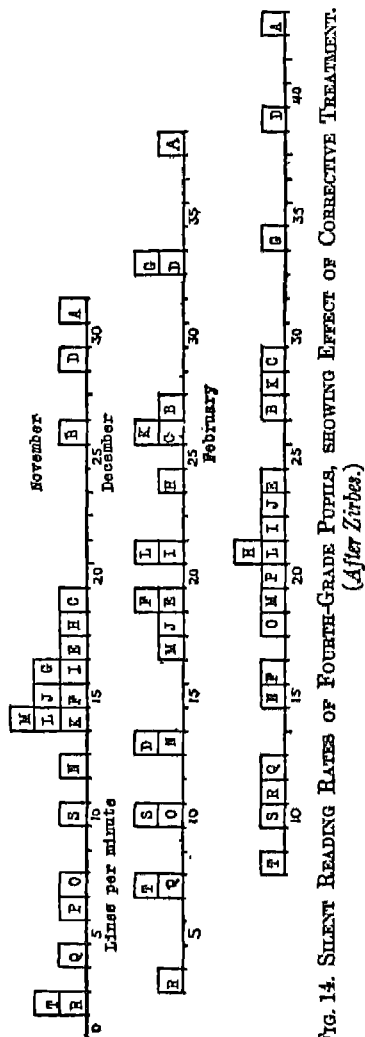
Fig. 14. Silent Reading Rates of Fourth-Grade Pupils, showing Effect of Corrective Treatment. (*After Zirbes.*)

increased, but the significant thing is that the low scores have been materially increased in most cases. The letters inside the small squares designate the different pupils. Pupil T has advanced from two lines a minute to eight lines a minute. Pupil R has gone from two lines to twelve lines. Pupil S has remained at ten lines. In Fig. 15 we have a graphical representation of one of the causes of this progress; that is, the average amount of supplementary silent reading done during school hours. The increase in the amount is very significant. It shows what can be done when an effort is made.
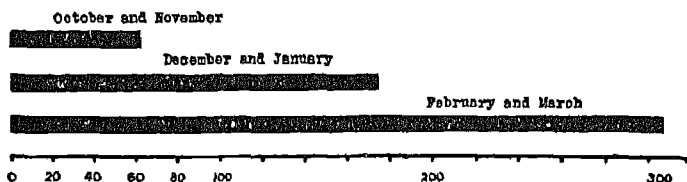
FIG. 15. AVERAGE NUMBER OF PAGES OF SILENT READING PER PUPIL DURING SCHOOL HOURS. SUPPLEMENTARY MATERIAL. (*After Zirbes.*)

Summary for Type III. When the scores of a class are widely distributed, individual instruction is required. Several illustrations of individual defects, the method of dealing with them, and the results have been given. One case of group instruction supplemented by individual instruction has been described.

Type IV. Slow readers and poor in comprehension in primary grades. The class record sheet of a second-grade class which was given the Courtis Silent Reading Test No. 2 is shown in Fig. 16. It is obvious that the pupils of this class both read very slowly and comprehend little of what they read.

The cause: over-emphasis on oral reading. The commonest of all reasons for this situation, particularly when

found in the grades below the sixth, is that the teachers have been placing chief stress upon oral reading. Where children are required to give their attention mainly to the correct pronunciation of words, the correct enunciation of sounds, and the correct inflection of the voice in passing

Table 1
Rate of Reading

Score in words per minute	Number of children making each score	
Over		
400		
380		
360		
340		
320		
300		
380		
360		
340		
320		
300		
280		
260		
240		
220		
200		
180		
160		
140		
120		
100		
80	3	
60	1	
40	5	
20	5	
0	1	
Total	15	
Median	45	

Index of Comprehension.

Diagnosis		Guesswork			Comprehension poor; additional training needed					Comprehension satisfactory	
Questions Answered	Total	Less than -5	-5 to +5	6-39	40-69	70-79	80-84	85-89	90-94	95-99	100
70											
65											
60											
55											
50											
45											
40											
35											
30											
25											
20											
15	2	2									
10	5	1		1	3						
5	8	3		1	2	1					1
0											
Total	15	6		2	5	1					1

Median Number of Last Question Answered 7 Median Index of Comprehension 34

Fig. 16. Showing the Scores of a 2A Class on the Courtis Silent Reading Test No. 2. (*Type IV.*)

over the several punctuation marks, not much growth in the power to comprehend the meaning in the printed page can be expected. Where the children study their reading lesson with the point of view of being able to respond in this way, they fasten upon themselves the habit of watching for words whose pronunciation they are not sure of, or they form the habit of reproducing the sounds of syllables, thus estab-

lishing the practice of moving the lips and other speech organs when reading silently. Frequently both these habits fix themselves upon children whose reading is judged mainly by the daily oral performance. When either or both habits become fixed, a real struggle is required to break them. Unless they are broken, however, the child suffers a severe handicap the rest of his reading life. Many men and women of mature years are still paying the price of those habits fixed in youth. They are able to read but little faster silently than they can pronounce the words orally, because their speech organs make all the motions of the successive words as the reading proceeds.

An illustration of the result of over-emphasis upon oral reading. Judd [1] gives the case of a girl in high school which illustrates the result of over-emphasis upon oral reading. The girl was getting on well in her school work, but "found it exceedingly difficult to keep up with her classes in home assignments." Reports from her various instructors brought out the following statements:

She is a very satisfactory student in French because she thinks clearly, studies thoroughly, and pronounces easily and correctly. The only drawback to her work is a lack of confidence in herself, which leads her to lose her head occasionally and feel that she knows much less than is the case. In English she is an appreciative and careful student, a little slow at times in getting a grasp of things. She has certainly no serious weakness up to this point and frequently offers hints of superior work. In mathematics she is in the better section and stands eighth among eighty-five students. In general science her work has been very satisfactory and her grades are high.

This girl is like many another student who is getting on all right so far as the school is concerned, but is doing it at great expenditure of effort.

She was tested with a series of passages both in oral and silent

[1] Judd, C. H., *Reading: Its Nature and Development.* Supplementary Educational Monographs (University of Chicago Press), p. 161.

reading. . . . The figures show that in general the rates of silent and oral reading are very much alike. . . .

There were marked tendencies to whisper all material read. She was much surprised when told not to do this and was sure she would not understand what she read because, as she said, she understood what she read only when she "heard" the words.

Table 1
Rate of Reading

Score in Words per Minute	Number of Children Making Each Score	
Over		
400		
380		
360		
340		
320	1	
300		
380		
360		
340		
320		
300		
280		
260	1	
240		
220	1	
200	4	
180	7	
160	4	
140	3	
120	6	
100	1	
80	2	
60	1	
40		
20		
0		
Total	31	
Median	176	

Index of Comprehension.

Diagnosis		Guesswork			Comprehension poor; additional training needed					Comprehension satisfactory	
Questions Answered	Total	Less than 5	-5 to +5	6-39	40-69	70-79	80-84	85-89	90-94	95-99	100
70											
65											
60											
55											
50											
45											
40	6							1	1	3	1
35	4						1			1	2
30	2						1	1			
25	4					1	1		1		1
20	11						2	4	1	3	1
15	4					1		1	2		
10											
5											
0											
Total	31					2	5	7	5	7	5

Rate of work satisfactory

Diagnosis: Rate of Reading too slow. Additional training needed.

Median Number of Last Question Answered 25 Median Index of Comprehension 91

FIG. 17. SHOWING THE SCORES OF A SIXTH-GRADE CLASS ON THE COURTIS SILENT READING TEST NO. 2. (*Type V.*)

The Remedy. The remedy for this type of situation, particularly below the sixth grade, is to place more emphasis upon silent reading. In doing this the suggestions given on page 59 will be helpful.

Type V. Slow readers with a satisfactory index of comprehension. Fig. 17 shows the record of a sixth-grade class which is deficient in rate of work. The median number of

words per minute is fifteen less than the standard and th median number of the last question is also fifteen below the standard. The index of comprehension is only four points below standard. These facts show that the pupils of this class read slowly and particularly answer questions slowly. However, they are careful readers as is shown by the index of comprehension. They need training in more rapid reading. The suggestions given on pages 66 and 68, apply to this type also.

VI. Correcting Defects in Oral Reading

The record of the scores of a class in the case of Gray's Oral Reading Test is not so helpful to a teacher as the records of the reading of individual pupils. This shows the types of errors which they made and a knowledge of them frequently will suggest the appropriate remedy.

An illustration of individual instruction in oral reading. The fourth-grade teacher from whose report we quoted on pages 79 to 81 also dealt with oral reading. The "group" instruction described on page 80 applied in part to oral reading. This was supplemented by seven types of individual instruction.

Type lesson 1. All look at the first phrase, looking up when they reach a comma or a period. When the entire group is looking at the teacher she nods and they repeat the phrase. She watches individuals to find their difficulties, but does not interrupt. When they have said all but the last word of the phrase they again look down, silently getting the next phrase and looking up, holding the phrase in mind until all are ready. Again the teacher nods and the group gives the phrase orally, looking down at the last word and continuing this procedure to the end of the paragraph or section.

The intensive study calculated to improve poor readers can be made to yield a double return, if, instead of selecting hard words and subjecting them to analytic study, the unit is the phrase or group of words which expresses an idea. Instead of working at a difficult word, the phrase in which it appears is studied until mas-

tered. Instead of working with one child at a time and giving each child only a few minutes of actual oral reading, four or five of those who have similar ability are grouped together, while other groups of poor readers follow silently. Third-grade material or very simple fourth-grade material is used for this purpose.

While other pupils are being tested, the ones who have had Type 1 answer mentally or in writing blackboard questions concerning the material of their lesson. Occasionally duplicated sheets containing uncompleted sentences or a story are used instead, the children filling in the blanks mentally or in writing.

Type lesson 2. Eye training and focus. Field of vision enlarged to include several words rather than one. First, by having the book far enough from the eyes. Secondly, by eliminating the use of a finger or other place-keeping device. Thirdly, by work with flash cards, flashing phrases, trying to get a phrase at one flash, and counting the number of flashes needed for each phrase. These phrases were cut from current printed matter and mounted on small cards. Written sentences directing children to perform certain activities were also used as flash material. The one who first read the direction carried it out. The one who had three such opportunities in succession was given a sheet with similar work for silent reading and could return to the group when finished.

Type lesson 5. Differentiation for pupils who confuse similar words or miscall syllables, guess at words, or omit endings. Lists like the following form the basis of such work. Lists are compiled from actual mistakes made by children:

that	woman	beautifully	swimming
when	every	prettiest	board
what	never	prettily	close
then	even	probably	chose
how	ever	lovingly	lying
who	very	companions	buying
their	these	understand	tired
there	those	understood	tried
than	now	laughingly	certain
women	know	quietly	curtain
man	beautiful	left	felt

Type lesson 6. Lessons in accuracy for those who make errors, substitutions, and omissions; reading a page orally and counting errors, or reading until they make an error to see how many lines they can read perfectly.

Type lesson 7. Breathing exercises. Children taught to breathe rhythmically at ends of phrases or clauses instead of breaking the smoothness of oral reading. Practice in breath control is thus related to the problem of meaning and interpretation. Abdominal breathing taught.

Type lesson 8. Articulation exercises for mumblers, or those with other bad speech habits.

Type lesson 9. Voice work and expression. Unpleasant voice quality and monotony corrected by special practice and training. Children are taught to vary meaning by change of stress and to show relative importance of ideas similarly. Punctuation is studied for the same purpose.

The Results. For oral reading very striking results were obtained. They are shown graphically in Fig. 18. The increase in the closeness of the grouping of the members of the class is significant as well as the progress made by the individual pupils.

The base line represents lines read per minute. The lettered blocks represent individuals. The group divisions are shown by vertical lines. Thus pupil O was in Group "D" and read five lines per minute in November, moved to Group "C" in December, and was reading nine lines per minute. In January he read twelve lines per minute and was in Group "B." In February he read thirteen lines per minute, but did not get into Group "A" until March. . . . The reading rate is an average of from three to five trials on as many selections of unstudied material from the Horace Mann *Reader*. No rate of measurement was made in April, as other reading tests were conducted.[1]

Interpretation of scores in ungraded schools. In rural schools or other ungraded schools classes are frequently so small that it is not wise to use the median or class scores. The interpretation is largely a matter of comparing the scores of individual pupils with the standards. In doing this certain facts should be kept in mind. First, the standards are median scores. For example, the standards for the fifth

[1] *Elementary School Journal*, vol. 18, p. 512.
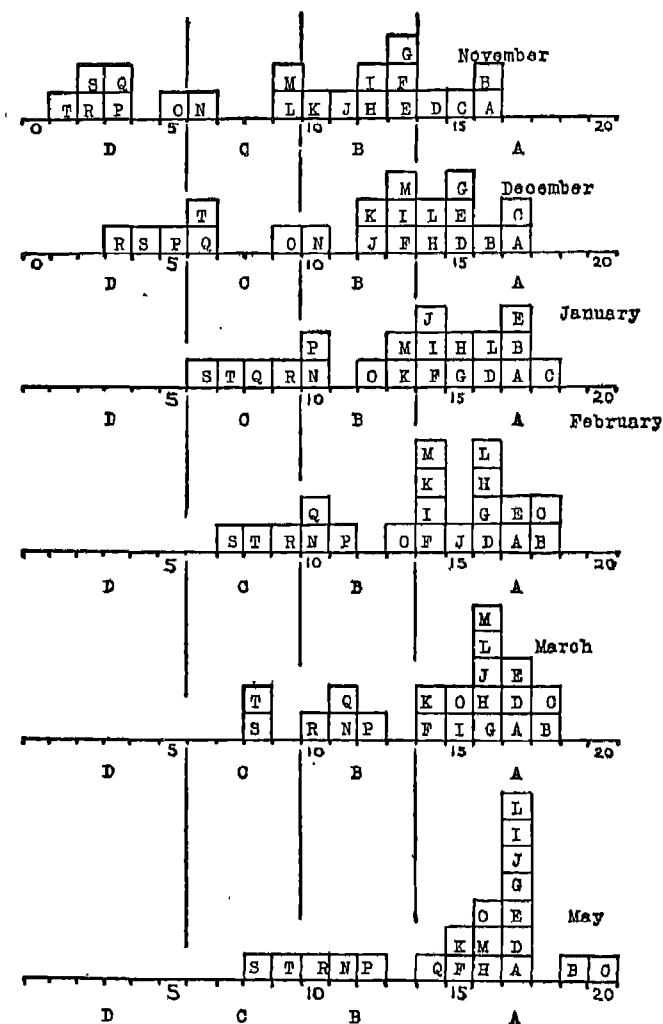
FIG 18. SHOWING IMPROVEMENT IN ORAL-READING RATE OF TWENTY-FOURTH WHEN INDIVIDUAL AND GROUP INSTRUCTION WAS USED. RATE EXPRESSED IN LINES PER MINUTE. (*After Zirbes.*)

grade are the median scores of several thousand fifth-grade pupils. Thus half of these pupils had scores greater than the standard scores and half of them had scores less than the standards. Second, pupils of the same grade differ widely in ability, and when the class scores are up to standard, half of the class will be above standard and half will be below. Third, in schools where only a few pupils belong to a grade, it may be that all are pupils of little natural ability, and hence should not be expected to have scores up to standard. On the other hand, it may be that they have a high degree of natural ability and should have scores distinctly above standard.

This makes the interpretation of the scores of individual pupils or of small groups of pupils difficult and somewhat uncertain. However, it is safe to say that when a pupil is distinctly below standard in rate or comprehension of silent reading, or both, his case should be carefully studied by the teacher. Much of what has been said concerning the causes of class weaknesses and the correctives for them also applies to individual pupils. Some pupils will be found to be high in rate, but low in comprehension (the rapid, careless reader; see pages 51 to 58); others will be low in rate, but relatively high in comprehension (the slow, plodding, but careful reader; see pages 65 to 68); still others will be low in both rate and comprehension (the slow, careless reader or one who has not learned to read; see pages 73 to 79).

Some pupils will be found who are distinctly above standard in both rate and comprehension. In such cases the teacher's problem is different. These have made satisfactory progress in silent reading under the instruction which they have been receiving and thus they require no special attention. The only case in which a modification of the instruction should be made is when a pupil who is above standard in silent reading is not doing satisfactory work in arithmetic,

spelling, or some other subject. Then he should spend less time reading and more upon the subject in which he is weak.

The rural teacher's opportunity for diagnosis and corrective instruction. When a teacher has a small number of pupils, he has an unusual opportunity for diagnosing his pupils and applying the required corrective instruction. Each pupil can be studied until his strong points and his weaknesses are known. Upon the basis of this information the teacher can easily apply the correctives because the instruction is largely individual anyway. The teacher who has twenty-five or more pupils in one class has much less opportunity to deal with individual pupils. When the teacher knows the scores of the pupils of his class on standardized tests, each pupil can be given that kind of instruction which he needs and under which he will make the greatest progress of which he is capable.

The use of standardized tests does not require a large amount of time. To teachers who may be interested in such diagnostic and remedial work this comment by the author of the above report is significant. (See pp. 79 and 86.)

> This study was not conducted by a specialist, but by a grade teacher interested in the advancement of the class through methods which reach the individual members. No time was taken from other studies. In fact a similar experiment in individual instruction was simultaneously carried on in spelling, arithmetic, and penmanship. The results were tested and are evidence that no one subject was over-stressed. The time economy, resulting from scientific procedure, also made possible a fullness and breadth of teaching usually thought incompatible with standardization and educational measurement.[1]

Summary. The ideas presented in this chapter may be summarized under three heads:

(1) *Service of standardized tests to the teacher.* By far the

[1] *Elementary School Journal* (March, 1918), p. 522.

largest service of standardized tests in reading is being rendered to the teacher. Not only are they enabling the teacher to check up his conception of what can justly be expected of children, but they are indelibly impressing upon his mind the absolute need for recognizing the individual differences among his pupils in respect to each problem of learning, and for studying the reading needs of his pupils in order to plan the instruction most wisely. In this chapter we have considered the meaning of certain types of class records, how to secure additional information concerning the reading abilities of pupils and the general correctives which should be applied to improve the standing of such classes. For certain cases we have given illustrations of the detailed diagnosis of pupils, the correctives which were applied, and the results which were obtained.

The distinction between silent reading and oral reading has been emphasized. The teacher should bear in mind that a pupil may read well orally from his reader, but may be doing poorly in geography or in the problems of arithmetic because he has not learned to read silently. These content subjects depend upon reading, but not upon the sort of oral word-pronouncing which still too largely characterizes our reading periods. Such a child needs a different sort of reading. He would be found to stand low, probably, in vocabulary; probably low in quality of silent reading. If the teacher has before him a chart upon which is recorded the standing of this child in the various aspects of reading, he will no longer assign for his study the next page or two in the *Reader*. He needs the sort of reading which widens his vocabulary more rapidly and centers his thought upon meaning instead of upon words.

As an illustration [1] of the aid of reading tests in such

[1] Uhl, W. L., "The Use of the Results of Reading Tests as a Basis for Planning Remedial Work"; in *Elementary School Journal* (December, 1916), vol. 17, no. 4.

diagnosis, the case of the Training School at Oshkosh, Wisconsin, may be cited. During a summer term of only six weeks, pupils, by use of the Kansas Silent Reading Tests, the Gray Oral Test, and the Gray Silent Reading Tests, had their difficulties localized. Instruction was then given upon the points revealed to be needing attention. Twenty out of one hundred and five children were given different instruction from that given the class as a whole. Surprisingly greater results were obtained in the case of those children whose instruction was specifically adapted to their difficulties.

(2) Service of standardized tests to the rural teacher. Standardized tests render a peculiar service to rural teachers by setting standards for them. A teacher who works in isolation from other teachers needs to know how her pupils compare with pupils in other schools. Since standardized tests have been widely used, they furnish a means by which any teacher can easily ascertain how her pupils stand in comparison with the established standards.

(3) Service of standardized tests to the child. Since the beginning of schools children have been sent to school to be taught. That being the case, they wait to be told what to do, and there is the end of their responsibility. When the end of the month comes they look to their report card for a measure of their success in doing what they have been told.

A function of standardized tests, by which the child can measure his own achievements about as successfully as the teacher can, is that they bring the child into partnership with the teacher in directing the whole educative process. If the child discovers by actual trial that he has only three fourths as large a vocabulary as children of his grade the country over, or that he reads only three fourths as fast, he can be depended upon better to coöperate in overcom-

ing the fault than when he is simply given a card every month with 70 assigned to his reading. Particularly is this true if he feels that at the end of a given period he can take his own measure again to ascertain his gain. Children should be enlisted with the teacher in the effort to select the most needful sorts of materials for their study. Where one child needs problem-solving, another needs a story, while still another needs something else than reading of any kind.

Service of standardized tests to the superintendent. Although this book is written primarily for teachers, it will not be out of place to call attention to the usefulness of standardized tests to the superintendent or supervisor. From the importance of reading in the general efficiency of all school work we may assume that the superintendent is vitally interested in making the instruction in reading most effective. What can reading tests reveal to him?

First, they can satisfy him and his teachers of the general status of reading in his district. It is easy for any superintendent to carry conviction among his teachers that the results in reading are not satisfactory in his district if he can show that among a group of a dozen or more neighboring cities his district stands low. The extent to which it stands low becomes a measure of the renewed earnestness needed in attacking the problem of improvement.

It is difficult for one to carry in mind a fixed standard of achievement. One gradually thinks more and more in terms of what those around him are achieving. It would have been quite impossible, for example, to convince the superintendent and teachers of the Anglo-Korean school at Songdo,[1] without a standardized test, that the children in their fifth

[1] Wasson, Alfred W., "Report of an Experiment in the Use of the Kansas Silent Reading Tests with Korean students"; in *Educational Administration and Supervision*, vol. 3, p. 98.

grade could do, on the average, reading work valued at only 3.8 units, while American children, who had been in school only the same number of years, could score 13.2 units, or that their sixth grade could accomplish only as much as the American third grade. It meant much to that school for its superintendent and teachers to be able to measure their school by the American standards.

Reveal wrong emphasis in teaching. Differences in the reading work done in the several buildings within a city may be as striking as differences among cities. In a certain Middle-Western town a forceful principal of one of the ward buildings has dominated the work of the building for a good many years. The reading of the building was his particular pride. When tested for silent reading ability his children scored in every grade but little more than half what the children in another building scored where the work was reputed to be "much less thorough." These results were made the basis of deliberations among the teachers as to the legitimate outcomes of reading, with the result that, without diminishing any one's zeal, the emphasis was transferred from oral word-pronouncing to silent thought-getting in the building where this strong principal dominates the work so effectually.

QUESTIONS AND TOPICS FOR STUDY

1. What are the chief methods by which adults add new words to their vocabularies? Are more new words learned from the context in which they appear, or from the dictionary? What can you say concerning the best way to increase the vocabulary of children?
2. What are some of the other factors besides vocabulary involved in silent reading? In what grades is vocabulary the most important factor? Make some suggestions for guaranteeing the intimate association of the mental concept which a word symbolizes, and the word itself when it is encountered in word drills.
3. What is the significance of rate in reading? Is there any truth in the rather common belief that one who reads slowly "gets more out of what he reads"? If you do not know the answer, can you devise some

way to test it out in your class? Compare your own silent reading rate with that of some equally well-educated friends.

4. What are the chief dangers involved in having much oral reading in the lower grades? Can these dangers be safeguarded? What types of reading matter do you now read orally outside the schoolroom? Are these the types which your pupils are asked to read orally?
5. What are the circumstances under which you last read aloud? Do your pupils have the same incentives for reading clearly and interestingly that you had on that occasion?
6. What are some of the things you do to assist your pupils in developing ability to comprehend the meaning of the printed page? Do you know of faulty habits which some of them have which prevent their centering attention upon the meaning? Do you know which pupils read with accuracy? Which with rapidity?
7. How long does it take you to become familiar with the reading difficulties of each child when you receive a new class of, say, thirty children? Would you consider it economical if some tests were available by means of which you could discover these difficulties as well as others the first day and thus prepare a chart of each child's instructional needs? How long at the beginning of a term could you afford to spend in making such a diagnosis?
8. Think of the last examination you gave in reading. Did it test satisfactorily what you are striving to teach in reading?

CHAPTER IV

THE MEASUREMENT OF ABILITY IN THE OPERATIONS OF ARITHMETIC

How arithmetical ability is measured. The plan of measuring the ability of pupils to do the operations of arithmetic is to have them do a set of examples[1] under specified conditions. In order that the scores may have a definite meaning, the test is limited to one type of example in one operation, as subtraction or multiplication or at most to a group of closely related types. The necessity for determining the value of the different examples in the test can be eliminated by constructing the examples so that they contain the same number of combinations; that is, in addition having each example involve twenty additions. The rate at which the pupil performs the operations is measured by timing the test as was done in the measurement of the ability to read silently. In the following pages we will describe two tests which have been devised to measure the ability of pupils to do the operations of arithmetic.

I. Courtis Standard Research Tests, Series B

Description of tests. The Standard Research Tests, Series B, or, as they are commonly called, the Courtis Arithmetic Tests, have been more widely used than any other instrument for measuring arithmetical abilities, and as a result we have better comparative standards for their use. The

[1] The word "problem" is used by some writers to designate both "example" and "problem." In this book the word "example" will be used to designate exercises which explicitly call for certain arithmetical operations. The word "problem" will designate only those exercises which require the pupil to determine first what operations are to be performed.

series consists of four tests, printed on four consecutive pages. They are suitable for a general survey of the abilities of pupils to perform the operations with integers. They are used in Grades four to eight.

Test No. 1. Addition

The twenty-four examples of this test have been constructed so that all have the same form, three columns of nine figures each. The following are samples. Time allowed, 8 minutes.

927	297	136	486	384	176
379	925	340	765	477	783
756	473	988	524	881	697
837	983	386	140	266	200
924	315	353	812	679	366
110	661	904	406	241	851
854	794	547	355	796	535
965	177	192	834	850	323
344	124	439	507	733	229

In giving the test the pupils are directed as follows:

You will be given eight minutes to find the answers to as many of these addition examples as possible. Write the answers on this paper directly underneath the examples. You are not expected to be able to do them all. You will be marked for both speed and accuracy, but it is more important to have your answers right than to try a great many examples.

Test No. 2. Subtraction

This test consists of twenty-four examples, each involving the same number of subtractions. The following are samples. Time allowed, 4 minutes.

107795491	75088824	91500053	87939983
77197029	57406394	19901563	72207316

Test No. 3. Multiplication

This test consists of twenty-four examples of this type. Time allowed, 6 minutes.

8246	3597	5739	2648	9537
29	73	85	46	92

Test No. 4. Division

This test consists of twenty-four examples of this type. Time allowed, 8 minutes.

25)6775	94)85352	37)9990	86)80066
73)58765	49)31409	68)43520	52)44252

Each of the examples of a test calls for the same number of operations under approximately the same conditions. This makes the examples of each test approximately equal in difficulty. Any example of the addition test, say the seventh, is just as difficult as any other, say the second. Thus, the tests consist of twenty-four equal units, just as a yardstick consists of thirty-six equal units (inches). The measure of a pupil's ability is represented by the distance he advances along the scale in the given time; that is, by the number of examples done and by the per cent of these examples which have been done correctly.

Since an example of one of these tests is defined as so many operations under certain conditions, it is possible to construct other tests equal in difficulty. Four forms have been constructed. This makes it possible to use a different form when the tests are given a second time.

Giving the tests. The general directions for giving reading tests also apply in the case of arithmetic. (See page 25.) Detailed directions accompany these tests. Since the same tests are given in all grades, a group of pupils belonging to

two or more grades can be tested together. It is only necessary to sort the papers according to classes when recording scores. If it is not convenient or desirable to give the four tests on one day, the test papers may be collected and returned the next.

Marking the papers. In marking the test papers, which is done by the use of a printed answer card that is run along across the page, no credit is given for examples partly right or for examples partly completed. This simple plan of marking the papers insures uniformity and accuracy. A pupil's score is the number of examples attempted and the number right. The number of examples attempted is a measure of the pupil's *rate of work*. By dividing the number right by the number attempted, the per cent of examples correct may be obtained. This is a measure of the *quality* or *accuracy* of his work. Thus, the two "dimensions" of the ability to do the operations of arithmetic are *rate* and *accuracy*.

Recording the scores of a class. For recording the scores of a class a record sheet of the form shown in Fig. 19 is used. This figure contains merely the blank for addition, but the forms for the other three tests of the series are identical with it. Detailed instructions for recording scores are printed on the record sheet. The large figures at the top of the sheet refer to the number of examples attempted and the small figures within the squares refer to the number of examples done correctly. The sheet is arranged so that the per cent of examples done correctly is computed automatically and the distribution of the scores according to both rate and accuracy is obtained at the same time. The scores of a seventh-grade class are shown in Fig. 19. The numbers written in certain of the squares represent the number of pupils whose scores fell within these divisions of the record sheet. The distribution according to rate is found at the bottom of the record sheet and is to be read thus: Three

Test No. 1. Addition. Standard Scores: Grade 3, 4; Gd 4, 6; Gd 5, 8; Gd 6, 10; Gd 7, 11; Gd 8, 12: Accuracy 100%

Score	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	Total	%
% 100	—	1	2	3	4	5	6 2	7	8 1	9	10	11	12	13 1	14 1	15 1	16	17	18	19	20	21	22	23	24	6	
90	Figures in small type indicate scores in number of examples right.		—	—	—	—	—	—	—	—	9 2	10 2	11	12	13	14	15	16	17	18	18–19	19–20	20–21	21–22	22–23	4	
Accuracy 80			—	—	—	4	5	6	7 2	8 1	8 4	9 3	10 2	11	12	12–13	13–14	14–15	15–16	16–17	16–17	17–18	18–19	19–20	20–21	12	
70			—	—	3	—	—	5 1	6	7 1	7 1	8 1	9	10 1	10–11	11	12	12–13	13–14	14–15	14–15	15–16	16–17	17–18	17–18	5	
60			—	2	—	3	4	—	5 1	6	6	7	8 1	8–9 3	8–9	9–10	10–11	11	11–12	12–13	13–13	13–14	14–15	14–15	15–16	5	
50			1	—	2	—	3 1	4 1	4 1	5 1	5	6	6–7	7	7	8	8–9	9–10 1	9–10	10–11	10–11	11–12	11–13	12–13	12–14	5	
0 to 49	0	0	0	0–1	0–1	0–2	0–2	0–3	0–3	0–4 1	0–4 1	0–5	0–5	0–6	0–6	0–7	0–7	0–8	0–8	0–9	0–9	0–10	0–10	0–11	0–11	2	
Total							3	2	5	4	8	6	3	5	1	1		1								39	

Median Scores: *Rate*______ *Accuracy*______ *Efficiency*______ *Standard Scores*______

For instructions, see other side of this page.

FIG. 19. SHOWING FORM OF TABULATION SHEET FOR RECORDING SCORES OBTAINED BY USING THE COURTIS STANDARD RESEARCH TESTS, SERIES B, AND THE SCORES OF A SEVENTH-GRADE CLASS IN ADDITION.

pupils attempted only six examples, two pupils attempted only seven examples, five pupils attempted only eight examples, etc. The distribution according to accuracy is found at the right-hand side of the sheet and is to be read thus: The per cent of examples done correctly by two pupils was less than fifty per cent, for five pupils it was between fifty per cent and sixty per cent, for five other pupils it was between sixty per cent and seventy per cent, etc. These two distributions, the one according to the per cent of examples done correctly and the other according to the number of the examples attempted, describe the ability of the pupils of this class to do the examples of the addition test.

Calculating the median score of a class. The central tendency (median) of the distribution of scores in the case of silent reading was found by arranging the test papers in order and counting up to the middle paper. The score on this paper was the median score. (See page 28.) This is not the best method to use here. For calculating the median, Courtis gives explicit directions in Folder D which is designed to accompany this series of tests. We give here general directions for finding the median so that they can be conveniently referred to.

The median is the mid-measure of a distribution. In the case of a distribution having an odd number of scores it is the value of the middle score. If there is an even number of scores it is halfway between the two middle scores.

Table XII gives a group of scores in the form of a distribution. The column labeled "Score" gives the scores arranged in order of magnitude. The column headed "Frequency" tells how many scores there are of each magnitude, or how frequently each score occurs. In this table there are two scores of 13, two scores of 12, five scores of 11, etc. The total number of scores is 45. The twenty-third score is the middle one, but it is not possible to identify its value di-

TABLE XII. SHOWING A TYPICAL DISTRIBUTION OF SCORES IN NUMBER OF EXAMPLES ATTEMPTED

Score	*Frequency* *
14	1
13	2
12	2
11	5
10	9
9	7
8	8
7	5
6	3
5	2
4	1
3	
2	
Total	45
Approximate median	9.0
Correction	.6
True median	9.6

* The frequency is the number of pupils making the score indicated. The scale consists of the scores arranged in order.

rectly. It is clearly one of the seven scores given as 9, because counting from the lower end of the distribution, 1 and 2 are 3, and 3 are 6, and 5 are 11, and 8 are 19, and 7 are 26, which is beyond the middle of the distribution. Therefore the approximate value of the median of this distribution is 9.0, which is the interval which contains the true median.

Rule for finding median. (1) Find the half sum of the distribution. In case there is an even number of scores, there is no middle score. In such a case the average of the two most central scores may be taken, although for practical purposes it will be satisfactory to take the lesser of the two middle scores. By doing this the calculation of the median is made simpler. Thus, if a distribution contains forty-one scores, the middle score is the twenty-first score; if it contains forty scores, the twentieth score may be taken as the

middle score.[1] The number of the middle score is obtained by dividing the total number of scores by two. This quotient, expressed as the nearest integer, is called the "half sum." When using a particular test the directions which accompany that test should be followed, because the medians used for standards have been obtained by following the accompanying directions.

(2) To determine the approximate median it is simply necessary to locate the interval of the distribution in which the median falls. To locate the interval in which the median falls, begin at the lower end of the distribution and add together the frequencies until the addition of the next one will make a sum greater than the number of the median score, or half of the total of the frequencies. This sum of the frequencies is called the "partial sum." The median score is in the next interval, and the approximate median is the value of that interval.

(3) To calculate the amount to be added to the approximate median to make the true median, proceed as follows: (1) Subtract the partial sum of the frequencies from the half sum. The partial sum is found in determining the approximate median. (2) Divide this difference by the number of scores which are included in the interval in which the true median falls. Add this quotient to the approximate median.

[1] There is a difference of practice on this point. The directions which accompany the Monroe Standardized Silent Reading Tests read as follows: "The median score is the score on the middle paper in the pile of papers arranged according to size of scores. If there are thirty-five papers, the median score is the score on the eighteenth paper. If there are thirty-six papers, the median score is halfway between the score on the eighteenth paper and the score on the nineteenth paper."

The directions which accompany the Courtis Standard Research Tests in Arithmetic, Series B, read as follows: "If there are thirty-seven children in the class, the nineteenth score in order of magnitude would be the median score; for there would be eighteen scores larger and eighteen smaller. If there were thirty-six children in the class, the eighteenth score would be taken as representing the nearest approximation to the middle measure."

If the width of the interval is more than one unit, the quotient must be multiplied by the number of units the interval contains. It is well to carry the quotient to two decimal places, but in writing the median it should be expressed only to the nearest tenth.[1]

The rule applied. In Table XII the half sum is 23. The approximate median is 9.0. The partial sum being 19, four of the seven scores in the 9-interval are required in order to reach the mid-point of the distribution. Four divided by 7 is .6, which, added to 9.0, gives 9.6 the true median.

Special cases. Although the rule given applies to all cases, there are a few special cases which sometimes give trouble. In Table XIII we show three special cases which may arise in using Series B. Case A is where the partial sum (13) is also the half sum (13). The approximate median is in the *next* interval (9). Since the difference between the partial sum and the half sum is zero, there is no correction and the true median is also 9.0. Case B is where the median falls in the first interval (0 to 49). It is only necessary to remember that the width of this interval is 50. Case C is where the median falls in the 100-interval. The width is zero. Hence the correction is zero.

Efficiency. Courtis has defined a measure of "efficiency." He says:

> The word "efficiency" as applied to education has, only too frequently, but little meaning. As used in connection with the Courtis Tests, however, it has a very definite meaning as soon as the following definition has been accepted: *The efficiency of any teaching process which has a measurable product is the per cent of the total product that measures up to the standard for the grade.*

For each test find the sum of all the frequencies equal to or exceeding the standard. Multiply this sum by 100 and divide by the total number of scores. The result will be the efficiency for that test.

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[1] See King, W. I., *The Elements of Statistical Method*, pp. 129–30; and Thorndike, E. L., *Mental and Social Measurements*, p. 54.

In Fig. 19 lines have been drawn to mark off those scores which are up to standard in both rate (11) and accuracy (100). There are three such scores. The efficiency of this class thus is 300÷39, or 7.7. However, many users of Series B do not believe the efficiency score has an important significance and it is not generally used.

TABLE XIII. SHOWING THREE SPECIAL CASES IN CALCULATING THE MEDIAN WHICH ARISE IN USING COURTIS'S STANDARD RESEARCH TESTS, SERIES B

A

Scale	*Frequency*
15	..
14	..
13	1
12	1
11	2
10	3
9	5
8	4
7	6
6	3
5	..
4	..
Total........	25
Approximate median	9.0
Correction..........	.0
True median........	9.0

B

Scale	*Frequency*
100	1
90– 99	..
80– 89	2
70– 79	2
60– 69	1
50– 59	4
0– 49	14
Total........	24
Approximate median	0.0
Correction..	43.0
True median.........	43.0

C

Scale	*Frequency*
100	15
90– 99	1
80– 89	4
70– 79	3
60– 69	2
50– 59	..
0– 49	..
Total........	25
Approximate median	100
Correction..........	0
True median........	100

Standard median scores. In Table XIV there are given three standard scores. (1) General median scores based upon distributions of "many thousands of individual scores in tests given in May or June, 1915–16. The distribution for each grade was made up of approximately equal numbers of classes from large-city schools and from small-city and country schools." (2) The standards proposed by Courtis after three years' use of these tests. (3) Boston standard median scores after the tests had been used for three years.

These standards are given in terms of rate and accuracy, which is the best form. However, for certain purposes it may be desirable to have them in terms of "number attempted" and "number right." The number of examples right can be found by multiplying the number of "examples attempted" or the rate by the accuracy.

With reference to the standards which he has proposed Courtis says:

The speeds [rates] set as standard are approximately the average speeds [rates] at which the children of the different grades have been found to work when tested at the end of the year, when for any one grade a random selection of five thousand scores from children in schools of all types and kinds are used as a basis of judgment.

Standard accuracy is perfect work, one hundred per cent. This is a tentative standard only, as there is available very little information in regard to the factors that determine accuracy and the effects of more efficient training.

At present in addition and multiplication it is only very exceptional work in which the median rises above eighty per cent accuracy, while in subtraction and division the limiting level is ninety per cent.

Standard speeds [rates] are not likely to change greatly. Standard accuracy is surely destined to approach much more nearly one hundred per cent than present work would indicate.

Standard scores are not only goals to be reached; they are limits not to be exceeded. It seems as foolish to overtrain a child as it is to undertrain him. All direct drill work should, in the judgment of the writer, be discontinued once the individual has reached standard levels. If his abilities develop further through incidental training, well and good, but the superintendent who, by repeated raising of standards, forces teachers and pupils to spend each year a larger percentage of time and effort upon the mere mechanical skills, makes as serious a mistake as the superintendent who is too lax in his standards.[1]

[1] Courtis, S. A., *Third, Fourth, and Fifth Annual Accountings, 1913–16* (Department of Coöperative Research, Detroit), p. 49.

TABLE XIV. STANDARD MEDIAN SCORES, COURTIS'S STANDARD RESEARCH TESTS, SERIES B

Grade	Addition		Subtraction		Multiplication		Division	
	Rate	*Accuracy*	*Rate*	*Accuracy*	*Rate*	*Accuracy*	*Rate*	*Accuracy*
IV. General	7.4	64	7.4	80	6.2	67	4.6	57
Courtis	6	100	7	100	6	100	4	100
Boston	8	70	7	80	6	60	4	60
V. General	8.6	70	9.0	83	7.5	75	6.1	77
Courtis	8	100	9	100	8	100	6	100
Boston	9	70	9	80	7	70	6	70
VI. General	9.8	73	10.3	85	9.1	78	8.2	87
Courtis	10	100	11	100	9	100	8	100
Boston	10	70	10	90	9	80	8	80
VII. General	10.9	75	11.6	86	10.2	80	9.6	90
Courtis	11	100	12	100	10	100	10	100
Boston	11	80	11	90	10	80	10	90
VIII. General	11.6	76	12.9	87	11.5	81	10.7	91
Courtis	12	100	13	100	11	100	11	100
Boston	12	80	12	90	11	80	11	90

Comparisons of class scores with the standards given in Table XIV or any others are valid only when the tests have been given under standard conditions. Slight changes in the method of giving the tests may affect the scores as much as the difference in the standards from one grade to another.

The interpretation of scores. The standards for Series B are to be used for the interpretation of individual and class scores in much the same way as the standards for the reading tests. The form of the class record sheet is convenient for interpreting the scores of the class. If one will draw a vertical line to represent the standard rate and a horizontal line to represent the standard accuracy for the grade, one can tell at a glance what the condition of the class is. See Fig. 21, page 120.

Graphical representation of the scores of a school. In Fig.

20 there is shown a scheme devised by Courtis for the graphical representation of the median scores of a city or school building. The position of the standards is shown by the circles along the dotted-line curve. The position of the median scores of a city is shown by the X's through which the solid-line curve passes. This is a very effective means for showing the condition within a city or school. The figure makes it very clear that the median scores for number of examples attempted are conspicuously below standard. The position of the first X which represents the fourth-grade scores is below and to the left of the fourth-grade circle. This means that the fourth-grade scores are below standard. The fifth grade shows an increase in accuracy but the pupils do not work more rapidly than those in the fourth grade. From the fifth grade to the sixth and from the sixth grade to the seventh growth is shown, principally in accuracy. For number of examples attempted the seventh grade is below the fifth-grade standards. The eighth grade shows an increase in rate of work but a marked decrease in accuracy.

II. Monroe's Diagnostic Tests

Arithmetical abilities distinct. A few years ago Stone[1] investigated the nature of ability in arithmetic and concluded that it was made up of a number of specific abilities. His conclusions have been corroborated by a number of other investigations,[2] and it is now reasonably certain that

[1] Stone, C. W., *Arithmetical Abilities and Some Factors Determining Them.* (Teachers College Contributions to Education, no. 19, 1908.)

[2] Kallom, Arthur W., *Determining the Achievement of Pupils in Addition of Fractions.* (School Document, no. 3, 1916. Boston Public Schools.)

Recently an investigation was made, under the direction of the writer, of the nature of the ability to place the decimal point in a quotient. This investigation showed that a number of specific abilities were involved, and not a single ability. See Monroe, Walter S., "The ability to place the decimal point in division," *Elementary School Journal,* vol. 18, pp. 287–93 (December, 1917).
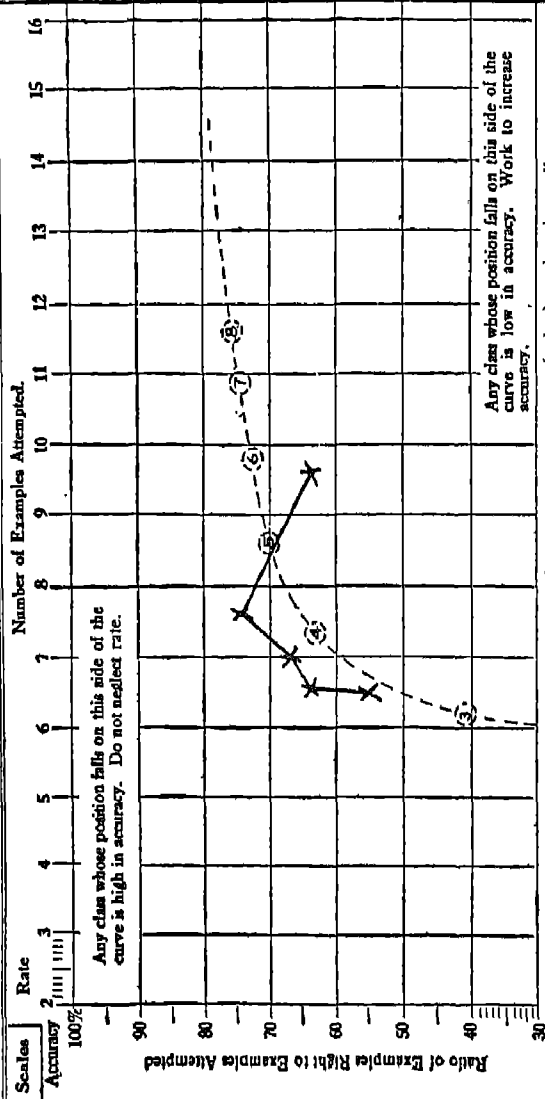
FIG. 20. SHOWING USE OF COURTIS'S GRAPH SHEET NO. 3.

in teaching the operations of arithmetic, we are attempting to engender a number of specific abilities which are relatively distinct, and not a single arithmetical ability. The word "ability" is used to refer to the rate and accuracy with which a pupil does a certain type of example. Teachers have recognized that pupils could do subtraction examples in which there was no "borrowing" when they were unable to do examples in which there was "borrowing," or that they could do short division when they were unable to do long division. The investigations of Stone and others have proven that there are as many different abilities as there are types of examples. In fact, it is obvious that the ability to add a column of three figures is not the same as the ability to add a column of twelve figures. In adding a column of figures it is necessary that one hold in mind the partial sum until he has added the next figure. This process must be repeated until the final sum is reached, and a failure to do this continuously will result in stopping the adding, at least temporarily. It is a frequent occurrence, for one who is not accustomed to adding long columns of figures, to find that he has stopped, perhaps has even lost the partial sum, and must begin again. The span of attention required in adding three figures is short, and pupils who are able to do examples of this type with a high degree of skill frequently are unable to add long columns of figures with an equal degree of skill. In fact, we have no reason to expect them to be able to do this type of example until they have practiced upon it.

Courtis,[1] the author of the Standard Research Tests, has identified the following types of examples in the operations with integers:

Addition: (1) addition combinations; (2) single-column

[1] Courtis, S. A., *Teacher's Manual for Courtis Standard Practice Tests* (1916.)

addition of three figures each; (3) "bridging the tens," as 38 + 7; (4) column addition, seven figures; (5) addition with carrying; (6) column addition with increased attention span, thirteen figures to the column; (7) addition of numbers of different lengths.

Subtraction: (1) subtraction combinations; (2) subtraction of 9 or less from a number of two digits, without "borrowing"; (3) same as the second, but with "borrowing"; (4) subtraction of numbers of two or more digits involving borrowing.

Multiplication: (1) multiplication combinations; (2) multiplicand two digits, multiplier one digit, and no carrying; (3) same as number 2, but with carrying; (4) long multiplication, without carrying; (5–8) zero difficulties, four types:

$$\begin{array}{r}560\\ \underline{40}\end{array}\qquad\begin{array}{r}807\\ \underline{59}\end{array}\qquad\begin{array}{r}617\\ \underline{508}\end{array}\qquad\begin{array}{r}703\\ \underline{60}\end{array}$$

(9) long multiplication, with carrying.

Division: (1) division combinations; (2) simple division, no carrying; (3) same as number 2, but with carrying; (4) long division, no carrying; (5–6) zero difficulties, two cases:

$$\begin{array}{r}690\\ 71\overline{)48990}\end{array}\qquad\qquad\begin{array}{r}302\\ 31\overline{)9362}\end{array}$$

(7) long division, with carrying, "first case, the first figure of the divisor is the trial divisor and the trial quotient is the true quotient":

$$\begin{array}{r}72\\ 63\overline{)4536}\end{array}$$

(8) "second case, where the trial divisor is one larger than the first figure of the divisor, but the trial quotient is the true quotient":

$$\begin{array}{r}63\\ 49\overline{)3087}\end{array}$$

(9) "third case, where the first figure of the divisor is the trial divisor, but the true quotient is one smaller than the trial quotient":

$$\begin{array}{r} 89 \\ 63\overline{)5607} \end{array}$$

(10) "fourth case, where the first figure of the divisor must be increased by one to obtain a trial divisor and the second trial quotient must be increased by one to get the true quotient)":

$$\begin{array}{r} 79 \\ 36\overline{)2844} \end{array}$$

Each a specific habit. Each of these types of examples requires a specific habit or automatism. To be sure, certain elements, such as the fundamental combinations, are common, but careful analysis will show that the ability to do examples of one type is different from that required to do another. Not only will a careful analysis reveal this fact, but it has been repeatedly demonstrated by carefully conducted investigations. In addition to the specific automatisms which are required for the four fundamental operations with integers, a number of other automatisms are required for the operations with fractions both common and decimal. At present we have only partial analysis of the examples in these fields, and for that reason it is not possible to state what types of examples are within the range of school work.

The significant characteristics of these abilities or automatic responses are the rate or speed of performance and the accuracy of the response. Thus, the measurement of arithmetical abilities involves determining only at what rate a pupil is able to do examples of the elemental types, and how accurate his answers are. This is accomplished by having him do examples of a given type for a specified time.

From his test paper his rate and per cent of examples correct may be determined. These two quantities represent the measure of his ability to do this type of example.[1]

Limitations of Series B. A complete and detailed measurement would require that a test be provided for each type of example, but fortunately certain combinations can be made. An example in addition consisting of three columns of nine figures each includes the addition combinations, simple column addition, and carrying. Thus, if a pupil responds satisfactorily to examples of this type, we know that he possesses the ability to do the types of addition examples involved therein. On the other hand, if his response to this type of example is unsatisfactory, we do not know just what elemental ability he lacks. The use of a single test of this type, such as Series B, to measure a group of arithmetical abilities has this very obvious limitation in diagnosing the conditions which exist, but it does provide a very satisfactory general survey.

Diagnostic Tests. Any series of classroom tests must not require a large amount of time if they are to be used by any besides the most enthusiastic workers. Thus, in constructing a series of diagnostic tests in the operations of arithmetic, due regard must be had for the amount of time that will be required. Bearing this fact in mind the writer has devised a series of twenty-one tests which require only thirty-one minutes of working time and which it is believed furnish a reasonably complete diagnosis of the abilities of pupils to do

[1] Strictly speaking, the number of examples done and the per cent of examples correct is a measure of the pupil's performance rather than of his ability. A pupil's performance is affected by many factors such as his emotional status, physical condition, light, temperature, and the like. Or, it may be that a pupil does not try to do his best on a given test. A pupil's ability can only be inferred from his performance, but when conditions are properly controlled, such inference is reliable in all except a few cases. In order to avoid an awkward form of statement and because the practice is general, we shall speak of a score as a measure of a pupil's ability.

the operations of arithmetic with the exception of the types of examples involving mixed numbers and integers with fractions. In order to avoid an excessive number of tests it has been necessary to include more than one type of example within a single test. When this has been done the different types are closely related and they always occur in rotation.

The following samples from each test will illustrate the types of examples included in the several tests:

Addition

Test I	*Test V*	*Test VII*	*Test XII*	*Test XV*
4	7862	7	1/6 + 1/3 =	1/6 + 3/5 =
7	5013	6	5/6 + 1/2 =	3/12 + 5/8 =
2	1761	6	3/10 + 3/5 =	
	5872	5	5/9 + 2/3 =	
	3739	0		
		5		
		1		
		8		
		7		
		3		
		3		
		1		
		2		

Subtraction

Test II		*Test IX*		*Test XIII*
87	94	789	1858	3/4 − 2/5
5	8	307	948	5/6 − 3/4

Multiplication

Test III	*Test VIII*		*Test X*		
6572	4857	560	807	617	840
6	36	37	59	508	80

Test XIV	*Test XVIII*		*Test XX*	
2/3 × 3/4	657.2	67.50	487.5	57.28
2/5 × 3/7	.7	.03	.62	9.5
5/12 × 3/5	46004	20250	302250	544160

In Tests XVIII and XX the pupil is simply to insert the decimal point in the product which is given. In the samples only the variations in the multiplier are given. Each multiplier is used with three types of multiplicands (657.2, 65.72, 6.572). Thus each test includes six types of examples.

Division

Test IV	*Test VI*	*Test XI*	*Test XVI*
8)3840	82)3854	47)27589	2/5 ÷ 1/3
			4/7 ÷ 2/3
			3/8 ÷ 2/3

Test XIX		*Test XVII*		*Test XXI*	
.4)148	*Ans.* :37	03)16 2	*Ans.* :54	.47)2758.9	*Ans.* :587
.9)65.7	*Ans.* :73	.07)1.82	*Ans.* :26	8.2)38 54	*Ans.* :47
.6)1.68	*Ans.* :28	.05).415	*Ans.* :83	79)30.893	*Ans.* :467
.7).301	*Ans.* :43	.06)7.44	*Ans.* :124		

Test XI is a composite test involving the four "cases" of long division given by Courtis. In Tests XVIII, XIX, and XXI the pupil is to write the answer in the proper place and insert the decimal point. In Test XXI each of the three types of divisor is placed with each of four types of dividends thus providing twelve types of examples.

Marking the test papers and tabulating scores. The test papers are marked in the same way as Series B. The scores are also recorded in the same way. Detailed directions accompany the tests.

Standards. Only tentative standards are available for these tests and they are likely to be changed somewhat in the future. For that reason they are not reproduced here. The best available standards are always furnished with the tests.

Graphical representation. A plan of graphical representation which makes very easy the interpretation of the scores of this series of tests will be given in the next chapter in our consideration of diagnosis. See Figs. 25 and 26.

Summary. In this chapter we have described two series of tests for measuring the abilities of pupils to perform the operations of arithmetic; Courtis's Standard Research Tests, Series B, and Monroe's Diagnostic Tests. The former is to be used for general measurement, the latter for diagnostic measurement. In describing these tests we have shown that ability to do the operations is specific. In the next chapter the meaning of the scores and correctives for the defects discovered by using the tests will be considered. In Chapter VI tests for measuring ability to solve problems will be described.

QUESTIONS AND TOPICS FOR STUDY

1. What is a general test? A diagnostic test?
2. When would you use a general test? A diagnostic test?
3. What is diagnosis?
4. How is the median calculated?
5. What is the "efficiency" of a class?
6. What are the "dimensions" of abilities to do examples?
7. What do we mean by saying abilities to do examples are specific?

CHAPTER V

DIAGNOSIS AND CORRECTIVE INSTRUCTION IN ARITHMETIC

Purpose of giving standardized tests is to furnish basis for improving instruction. As in the case of reading, the fundamental purpose of giving standardized tests in arithmetic is to secure information which the teacher may use in improving the instruction. Series B can be used to secure general information concerning the abilities of the members of a class. The scores will tell the teacher, for each of the four operations, whether his pupils are above or below standard in rate of work and in accuracy. With this information at hand, the teacher knows where he should place the emphasis in his instruction; that is, whether he is devoting insufficient time to practice upon the operations, or whether the pupils are being drilled when they are already up to standard, or whether he should place more emphasis upon the rate of work or upon accuracy.

However, when we recall the nature of ability in the operations of arithmetic, it appears that Series B cannot furnish as complete information as is necessary for planning details of instruction, such as the types of examples which should receive emphasis. A more elaborate series, such as Monroe's Diagnostic Tests, is necessary. In certain cases it is very helpful to supplement the diagnostic tests with an analytical diagnosis.

In this chapter we shall consider (1) the meaning of scores obtained by using Series B and the instruction which should be given to correct the conditions revealed; (2) the use of the Diagnostic Tests and how to use the results; (3) supplementary or analytical diagnosis.

I. Courtis's Standard Research Tests, Series B

Type I. Below standard in both rate and accuracy. The causes. There is given in Fig. 21 the record of a fifth-grade class for the addition test. The standards have been indicated by drawing heavy lines. The four divisions into which these lines divide the record sheet make the interpretation of the groups more simple. The records of this class for the other three tests are similar, showing that it is rather conspicuously below standard in both rate and accuracy. Several causes for this condition are possible. The pupils may not know the tables. They may not have learned a good method of work. They may lack sufficient effective drill upon these types of examples. In the absence of scientific information on this point it is the writer's opinion that the last-mentioned cause is the most probable. Saying that the most probable cause is insufficient drill does not necessarily mean that not enough time has been given to drill. Much time may be given to drill and the drill not be effective because the teacher uses a poor classroom procedure.

An illustration of inefficient drill. Frequently the writer has visited classes in arithmetic which were being drilled upon the fundamental operations. A fairly uniform procedure was followed. The same example was dictated to all of the pupils, regardless of whether they needed drill upon this particular type of example or not. Naturally some pupils finished very quickly, and, as they waited for their classmates to finish, there was a tendency for them to become disorderly — a perfectly natural tendency. When a majority of the class had finished the example, the teacher stopped the work and read the correct answer. The process was then repeated. The result was that those pupils who worked slowly completed few, if any, examples during the entire period, and, therefore, received little satisfactory

Test No. 1. Addition.

Score	Score in number of Examples Attempted: 0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	Total	%
% 100	—	1	2	3	4	5	6	7	8	9 (1)	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	1	
Accuracy 90	Figures in small type indicate scores in number of examples right.		—	—	—	—	—	—	—	—	9	10	11	12	13	14	15	16	17	18	18–19	19–20	20–21	21–22	22–23		
80			—	—	—	4	5 (2)	6	7 (1)	8	8	9	10	11	12	12–13	13–14	14–15	15–16	16–17	16–17	17–18	18–19	19–20	20–21	3	
70			—	—	3 (1)	—	—	5 (1)	6 (1)	7 (1)	7	8	9	10	10–11	11	12	12–13	13–14	14–15	14–15	15–16	16–17	17–18	17–18	4	
60				—	—	3	4 (1)	—	5 (1)	5	6 (2)	7 (1)	8	8–9	8–9	9–10	10–11	11	11–12	12–13	12–13	13–14	14–15	14–16	15–16	5	
50			1	—	2	—	3	4	4 (1)	5 (1)	5	6	6–7	7	7	8	8–9	9–10	9–10	10–11	10–11	11–12	11–12	12–13	12–14	2	
0 to 49	0	0	0 (1)	0–1 (1)	0–1 (2)	0–2 (5)	0–2 (4)	0–3 (2)	0–3	0–4 (1)	0–4	0–5	0–5	0–6	0–6	0–7	0–7	0–8	0–8	0–9	0–9	0–10	0–10	0–11	0–11	16	
Total			1	1	3	5	7	3	4	4	2	1														31	

Median Scores: *Rate* 6.9 *Accuracy* 50 *Efficiency* 3 *Standard Scores* ______

Fig. 21. (*Type I.*) The Record Sheet of a Fifth-Grade Class in Addition. Below Standard in both Rate and Accuracy.

drill. The bright pupils spent a considerable portion of their time waiting on the other members of the class, and probably did not need the particular kind of drill which they received.

Some teachers spend a great deal of time in having examples explained by pupils, the explanation consisting merely of an oral reproduction of the process of adding, subtracting, etc. There is a time in the learning process when pupils need explanation, but in the operations of arithmetic, after they understand what to do, attentive repetition is required. This requires an efficient plan of drill. Another point which should be noted is that the drill must be upon all the types of examples which they are to learn to do and not upon the tables or some other single type.

The remedy. (*1*) *A modified classroom procedure.* The type of class instruction described on page 120 can easily be modified so as to make the drill more efficient and to insure that the slow-working pupils will get some satisfactory drill. Instead of dictating only one example at a time, the teacher can dictate several, and stop the work as soon as a few of the faster workers have finished. The slow-working pupils will have some examples completed and the faster workers will not have been idle.

(*2*) *Rate of work must be recognized.* The teacher must recognize that the rate at which the pupil performs the operations is important, as well as the accuracy. This means that, in teaching, the teacher must obtain a measure of the pupil's rate, as well as a measure of his accuracy. If examples are dictated in groups, and the work stopped as suggested in the above paragraph, the number of examples which the pupil does during the class period is a measure of his rate of working. The per cent correct is a measure of his accuracy.

(*3*) *Motivation.* Another means of increasing the scores of

a class is to secure a strong motive for the work. Arithmetic is one of the best liked of the drill subjects. This is particularly true of the operations. This being the case, the motivation of drill in arithmetic generally is a comparatively simple matter, and in most cases it will be sufficient simply to start the pupils to work and to keep the work from lagging. When more than this is necessary, the teacher must demonstrate her resourcefulness by providing an effective method or device for the motivation of arithmetical drill. In the lower grades the playing of certain games provides practice upon certain types of examples. In the upper grades ciphering-matches, or, better, the setting of definite standards in both rate and accuracy, are very effective motives.

Standards used to motivate work in arithmetic. The writer has visited classrooms in which the teacher had posted a chart giving the median scores of the class at the beginning of the school year and the standards which should be reached by the end of the year. Teachers testify that this is an effective means of stimulating interest. Figures in the latter part of this chapter illustrate plans for representing the standing of a class on a chart.

Type II. Below standard in rate with satisfactory accuracy. Sometimes a class will be found with a satisfactory median score in accuracy, but conspicuously below standard in rate of work. This condition may be due to the fact that, through the neglect of the rate of work by the teacher, the pupils have not been trained to work rapidly. It may be due to the pupils having the habit of applying some check to their work or doing it a second time. Some pupils work slowly because they are not concentrating their attention upon what they are doing. In giving tests the writer has observed pupils stop and look around the room or out of the window, showing thereby that they were working at a very

low pressure. Other pupils have been found to work slowly because they have acquired inefficient methods of work. One such method which is frequently found is the use of an elaborate phraseology or formula in performing the operations. (This cause is treated more fully on page 149.)

The remedy for this type of situation is primarily to place more emphasis upon the rate of work in classroom drills. The pupils should be given timed drills and judged upon the basis of their rate of work as well as the accuracy of their results. The modified classroom procedure suggested above makes this possible. If pupils have acquired habits of work that are undesirable, such as counting on the fingers or tapping out sums or repeating the numbers to be added, subtracted, etc., they should be corrected. Also a strong motive will tend to increase the rate of work. In increasing the rate of work, care must be exercised to make certain that the pupils do not become inaccurate. However, as in the case of silent reading, high rate and high accuracy are not incompatible. In fact they frequently go together, and frequently an increase in the rate of work in arithmetic is accompanied by an increase in accuracy.

Type III. Below standard in accuracy with satisfactory or high rate. If one takes the position that the only satisfactory standard for accuracy is one hundred per cent, this case occurs very frequently. If one accepts the general medians of Table XIV as satisfactory standards, it occurs much less frequently. In this discussion we shall accept the general medians as satisfactory standards. A median score in accuracy may be below standard because the test was given to the pupils in such a way that they became excited and worked very rapidly when they were accustomed to work slowly. When it is suspected that this is the cause, the test should be repeated, using a different form, and exercising care not to excite the pupils. Pupils should become

accustomed to working under timed conditions by being timed in doing the regular class exercises.

Another reason for a low median score in accuracy may be the lack of sufficient practice upon the types of examples used in these tests. If this is the cause, the remedy is obvious, and the suggestions given above in respect to effective methods of drill will apply.

Type IV. Scores too widely scattered. An illustration is given of this type of situation in Fig. 22. The median rate of this class is above standard and the median accuracy is only slightly below. Thus, as judged by its median scores the standing of this class is satisfactory, but the scores are not closely grouped about the central tendencies. Although the class is relatively small the rates of work vary from four examples to seventeen examples and the accuracy scores are recorded in each interval of the record sheet. This is an illustration of a condition which prevails to some extent in practically every class. Unless the class is very small, there will be a distribution of scores extending over several intervals of the record sheet.

The overlapping of the several grades. When the distributions of the scores for successive grades are compared, a great overlapping is found. Some pupils in the fourth grade make higher scores than a number of the eighth-grade pupils. Table XV shows the distribution of pupils in a certain city according to the number of examples attempted in the subtraction test of the Courtis Standard Research Tests, Series B. An examination of the table on page 126 reveals these facts:

In the fourth grade twenty-three per cent of the pupils reach or exceed the fifth-grade median.

In the fifth grade twenty-three per cent of the pupils reach or exceed the sixth-grade median.

In the sixth grade twenty-four per cent of the pupils reach or exceed the seventh-grade median.

Test No. 3. Multiplication.

Score	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	Total	%
% 100	—	1	2	3	4	5	6	7 / 1	8	9	10	11 / 1	12	13	14	15	16	17	18	19	20	21	22	23	24	2	
90	Figures in small type indicate scores in number of examples right.		—	—	—	—	—	—	—	—	9	11 / 2	11 / 1	12	13 / 1	14	15	16	17	18	18–19	19–20	20–21	21–22	22–23	4	
80			—	—	—	4	5	6	7	6	8	9	10 / 2	11 / 1	12	12–13	13–14	14–15	15–16	16–17	16–17	17–18	18–19	19–20	20–21	3	
Accuracy 70			—	—	3 / 1	—	—	5	6	7	7	8	9	10 / 1	10–11	11 / 1	12	12–13 / 1	13–14	14–15	14–15	15–16	16–17	17–18	17–19	4	
60			—	2	—	3	4	—	5	6 / 1	6	7 / 1	8.	8–9 / 1	8-9 / 1	9–10 / 1	10–11	11	11–12	12–13	12–13	13–14	14–15	14–16	15–16	5	
50			1	—	2	—	3 / 1	4	4	5 / 1	5	6	6–7	7	7	8	8–9	9–10	9–10	10–11	10–11	11–12	11–12	12–13	12–14	2	
0 to 49	0	0	0	0–1	0–1	0–2	0–3	0–3 / 1	0–3	0–4	0–4	0–5	0–5	0–6	0–6	0–7	0–7	0–8	0–8	0–9	0–9	0–10	0–10	0–11	0–11	1	
Total					1		1	2		2		4	3	3	2	2		1								21	

Median Scores: *Rate* 12.3 *Accuracy* 78 *Efficiency* 5 *Standard Scores* ______

Fig. 22. (*Type IV.*) The Record Sheet of an Eighth-Grade Class in Multiplication. Scores too widely scattered.

TABLE XV. SHOWING THE DISTRIBUTION OF THE PUPILS OF A CITY ACCORDING TO THE NUMBER OF EXAMPLES ATTEMPTED, COURTIS'S STANDARD RESEARCH TESTS, SERIES B

Subtraction

Grade	*Number of examples attempted*																				
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	*Median*
IV..	1	7	11	17	19	18	10	8	4	4	1	..	..	..	..	..	.	.	..	..	5.7
V..	..	1	3	9	10	18	23	21	8	2	3	2	..	..	..	..	..	..	..	..	7.4
VI..	..	..	1	2	8	9	20	16	14	14	9	1	4	2	..	..	..	..	..	..	8.6
VII..	..	..	1	..	2	6	9	13	12	16	14	12	6	5	2	1	..	..	1	..	10.4
VIII..	..	..	..	1	..	..	9	13	8	19	12	15	8	5	2	3	2	2	..	1	11.0

In the seventh grade forty per cent of the pupils reach or exceed the eighth-grade median.

This condition is merely typical. Three causes may be given: (1) imperfect classification of pupils; (2) native individual differences in the pupils; and (3) the training which they have received. As a rule only a few cases can be accounted for on the basis of imperfect classification when we remember that except where the school has been departmentalized, the pupils have been grouped not only for instruction in the operations of arithmetic, but also for instruction in other subjects, and that pupils who are low in arithmetic may stand high in some other subjects. Native differences remind us that pupils are different and that complete uniformity cannot be secured. It is, therefore, the third cause which concerns us most.

The effect of class instruction not suited to all pupils. The effect of class instruction is shown when a test is repeated after an interval of a few months. In Table XVI the midyear[1] distributions for a certain city on the addition test of

[1] The first test was given just after the midyear promotions. The tests were given to about one hundred and fifty pupils in each grade.

TABLE XVI. THE RANGE OF NUMBER OF EXAMPLES ATTEMPTED
(Upper numbers for each grade are for the mid-year test. Lower numbers refer to the May test.)

Addition

Grade	*Total range*	*Range in number of examples*	*Range of middle 50 per cent*	*Range in number of examples*
IV............	1-10	10	3.6- 5.9	2.3
	1-17	17	5.0- 8.3	3.3
V............	2-14	13	4.7- 7.0	2.3
	3-16	14	6.8- 9.0	2.2
VI............	2-12	11	5.7- 8.4	2.7
	4-24	21	7.2-11 0	3.8
VII............	3-24	22	6.9-10.0	3.1
	4-24	21	8.5-12.3	3.8
VIII............	4-18	15	8.1-10.8	2.7
	5-17	13	8.9-12.1	3.2

Series B are compared with those for May. With only two exceptions both the total range of the scores and the range of the middle fifty per cent were increased. This fact shows that the instruction in addition which these pupils received was more appropriate for the brighter pupils than for those who were below standard ability. Some pupils acquired abilities far in excess of the standards for their grade, while others remained conspicuously below the standard. This is merely what we should expect, because those pupils who have profited most under the system of instruction may be expected to continue to profit most. Obviously, if our standards are wisely determined, the pupils who are below standard in ability need instruction and those who are conspicuously above standard may spend their time more wisely upon other subject-matter. If this is not feasible, the methods and devices of instruction should be those most

appropriate to those pupils who are below standard. If the methods of instruction are unchanged, it is obvious that the pupils who have learned most readily will continue to do so.

The bright pupil should receive consideration as well as the backward pupil. The usual class instruction does not give the bright pupil efficient training. He is not forced to exert himself. Much of the time he is forced to be inactive. Furthermore, in the case of the tool subjects (the operations of arithmetic, reading, spelling, handwriting, and language), training beyond a certain point is not very profitable. In arithmetic the bright pupil should be given problem work rather than additional training upon the operations.

The remedy. Where reclassification of the pupils is possible and appears wise in the light of the achievements of the pupils in other parts of arithmetic and in their other subjects, a closer grouping can be secured by promoting those who are conspicuously above standard. Some may be put back a grade. But it will be found that many pupils will be below standard only in certain items. To handle these cases, individual, or at least group, instruction is required, because it is obvious that all members of the class do not need the same instruction. Before individual instruction can be wisely planned, additional information concerning the members of the class is needed. This may be secured (1) by using diagnostic tests and (2) by analytical diagnosis. We shall therefore treat Type IV more fully under the head of Diagnostic Tests.

Type V. Irregular development. Fig. 23 shows the median scores of two classes in a certain city. In the number of examples attempted, Class A is nearly three examples higher in subtraction and multiplication than in addition. Class B has very high scores in addition, but lower ones in the other operations, particularly multiplication and division. The relative position of the line showing the median number of

examples right shows Class A to be inaccurate in all operations except division, where perfect or one hundred per cent accuracy is indicated. On the other hand, Class B, which in general is relatively very accurate in the other operations does not attain perfect accuracy in division. Such irregular or uneven development is not unusual. It is more frequent and more pronounced in individual pupils than in classes.

Fig. 23. Showing Median Scores of Two Classes in the Same City. (*After Ashbaugh.*)

In Fig. 24 we show the records of a girl who was tested twice with Series B, first, as she was finishing the seventh grade and again as she was completing the eighth grade. In the figure her records are indicated by broken lines and the position of the eighth-grade standards (Boston) are shown by the solid line. In the seventh grade this girl's development was irregular. In subtraction she had fourth-grade ability (see Table XIV), and in addition she was about fifth-grade. In division she was above eighth-grade ability.

Such uneven development in either a class or an individual pupil is probably caused by not properly distributing the

FIG. 24. TWO RECORDS OF ONE GIRL. (*From Ballou.*)

Instructions: On each horizontal line after the word "Attempts," place a dot under the figure representing the number of examples you have tried, and on the line after the word "Rights," place a dot under the figure representing the number of examples that you had right. Beginning with the figure at the top that represents your grade, draw a line *through all the dots* that you have made.

drill. A study of the median scores of a class on the several tests of the series will tell the teacher where the most emphasis should be placed in the class instruction. A study of the records of a pupil will furnish information for planning individual instruction. In Fig. 24 the broken line drawn for the eighth-grade scores shows that the development of this pupil was evened up during that grade. Such complete evening-up of scores is unusual, but if the teacher places emphasis upon the operations in which low scores are made marked improvement will result.

II. Monroe's Diagnostic Tests

More detailed information is secured by using diagnostic tests. An illustration of the irregular development of a class. By using the diagnostic tests described on page 114, more detailed information can be secured concerning a class or a pupil. In Fig. 25 the median scores of three sixth-grade classes in one city are represented. The plan of graphical representation is similar to that used in Fig. 7. The two scores of a test are represented on the sides of an elongated rectangle, the number of examples attempted on the upper side and the number right on the lower side. The scale on each line has been chosen so that the standard scores of the twenty-one tests for a given grade fall on a straight vertical line. Thus the sixth-grade standards all lie on the vertical line drawn from VI, seventh-grade standards on the vertical line drawn from VII, etc. The scale on the lines has been omitted in order to prevent the crowding of the figure. The numbers and letters at the left of the figure give the number of the test and the operation.

Series B has been used for several years in the city from which the sixth-grade records shown in Fig. 25 were taken, and we may therefore assume that conditions are as good or possibly better than in the average city. Classes A and
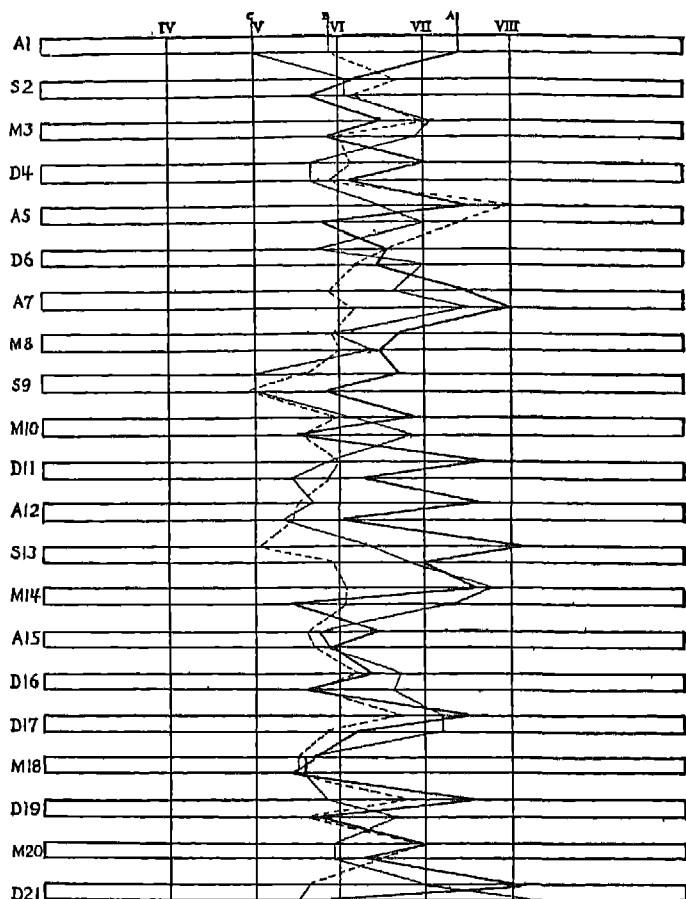
Fig. 25. Showing the Median Scores of Three Sixth-Grade Classes.

B have thirty-three pupils each and Class C twenty-three pupils. The figure shows two significant facts: (1) certain points of non-uniformity between the medians of the three

classes, and (2) the non-uniform abilities of any one of the classes.

In certain of the tests, such as 2, 6, 8, 15, 18, and 20, the median scores of three classes fall within an interval of about one grade. In others, notably Tests 13 and 21, the extreme difference is much greater. Evidently the teachers of the different classes have not been placing equal emphasis upon the different types of examples. Take, for example, the addition tests (1, 5, and 7). The teacher of Class B has been placing much emphasis upon the type of example in Test 5 (short-column addition with carrying), although it should be noted that she has not neglected the other types of addition examples. On the other hand, the teacher of Class C has neglected short-column addition (Test 1), while the teacher of Class A has given much emphasis to it. In Test 7 there are represented three degrees of emphasis.

The non-uniform character of the abilities of a class is very obvious from the irregularity of the lines representing their abilities. Perfect uniformity would be represented by a straight vertical line. The non-uniformity in the abilities is due to the failure of the teacher to place the appropriate degree of emphasis upon the several types of examples. Some types doubtless require more emphasis than others, and it is the teacher's problem (or is it the problem of the maker of the course of study?) to determine the degree of emphasis which is needed for each type.

An illustration of the irregular development of pupils in the same class. In Fig. 26 there are shown the scores of three sixth-grade pupils selected almost at random from Class A in Fig. 25. H. H. is a twelve-year-old boy, H. C. a ten-year-old girl, and D. H. a girl, age not given. One should expect greater variations when dealing with the scores of individual pupils, but the variations of these scores must be surprising to one who has not studied the subject. Each
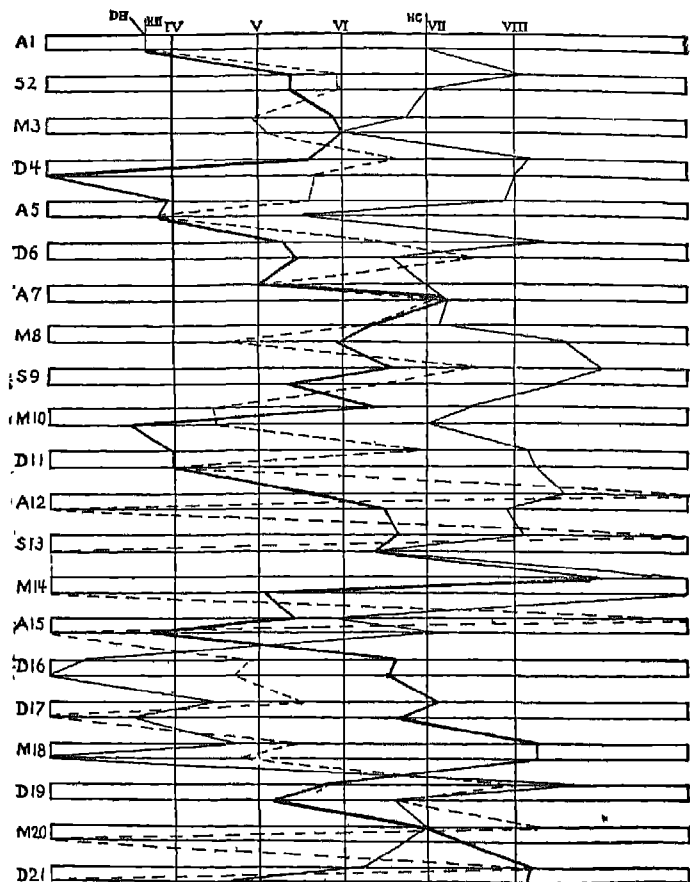
FIG. 26. SHOWING THE INDIVIDUAL SCORES OF THREE SIXTH-GRADE PUPILS IN THE SAME CLASS.

Class A in Fig. 25.

of these pupils has scores on certain tests conspicuously below the standard for the fourth grade and on other tests has scores conspicuously above eighth-grade standards.

Since these pupils were members of the same class, they had probably received the same instruction, and yet the instruction which had been sufficient for one had not always been satisfactory for the others. Pupils differ in the instruction which they need. The instruction which will cause one pupil to learn may make no impression on another.

Arithmetic a complex subject. The facts described above show that the product of arithmetical instruction is complex, much more complex than teachers and supervisors generally realize. The fact that the scores obtained by using these tests show such great variations in the relative degree of ability in the different types of examples, when the pupils have been measured with the Courtis Standard Research Tests, Series B, at regular intervals, is evidence of the need which exists for a series of diagnostic tests. Teachers are probably failing to place the appropriate degrees of emphasis upon the different types of examples, because they are ignorant of what types exist, or do not know the degree of ability which has been attained by their class, and much less the degree of ability attained by the individual pupils. A series of diagnostic tests, such as described in chapter IV, are valuable to the teacher in two ways: (1) as a statement of the important types of examples, and (2) as an instrument for diagnostic measurement.

An illustration of individual instruction. To correct the individual defects individual instruction is needed. A teacher can fit his instruction in the operations of arithmetic to the needs of his pupils by preparing a number of sets of examples, each set being confined to examples of the same type. These sets of examples should be written on cards. Then, instead of dictating examples, the teacher can distribute the cards and have the pupils copy the examples from the cards. If the teacher studies the needs of his pupils, it will be possible for him to distribute the cards so

that each pupil will have the type of example upon which he needs practice. The pupil is probably injured by being required to practice upon the wrong type of example, and, hence, it is very important that each pupil be given the type of example upon which he needs practice.

The Courtis Standard Practice Tests used for individual instruction. Courtis has devised a set of Standard Practice Tests,[1] which automatically diagnoses each pupil and furnishes the practice which he needs to remedy his defects. These tests consist of forty-eight sets of exercises, which "have been designed to cover every known difficulty in the development of ability in the four operations with whole numbers." The latest form of these tests (1916) is arranged so that the pupils begin the series by taking Lesson 13, a test involving all types of examples found in the first twelve lessons.[2] All pupils who attain standard ability on this test are excused from the first twelve lessons, because they have demonstrated that they do not need the instruction which these lessons provide. As soon as a pupil who did not attain standard ability on Lesson 13 has finished the first twelve lessons, he takes Lesson 13 again to show that he is now up to standard. Lessons 30, 31, and 44 are also test lessons, and are used in the same way.

Each of the lessons is printed upon a card and a copy is furnished to each pupil. The card is placed beneath a sheet

[1] Full details regarding these tests may be obtained from the publishers, World Book Company, Yonkers, New York, and Chicago, Illinois.

Another series of exercises, known as the "Studebaker Economy Practice Exercises," and based upon some of the same general principles, has been devised by J. W. Studebaker, Assistant Superintendent of Schools, Des Moines, Iowa. They are published by Scott, Foresman & Company, New York and Chicago. Other series of practice exercises have been devised, but, so far as the writer has examined them, they are less complete and give less promise of efficient means of instruction.

[2] All lessons except the test lessons are confined to a single type of example.

of transparent paper and the example is read through the paper, the work being done on the paper. The lessons have been constructed so that the standard length of time required to complete each one is the same. They are also self-scoring. These two features relieve the teacher of the laborious work of scoring the papers, and make it possible for different pupils to be working upon different lessons at the same time. Thus, when a pupil has demonstrated that he is up to standard on any type of example, he may at once go on to the next lesson. If he is not up to standard on any lesson, his work makes the fact obvious, and he can remain upon that lesson until he acquires the necessary ability without interfering in the least with the work of the other members of the class.

Thus, individual progress is provided for, and at the same time the group formation is retained. A considerable saving of pupils' time is effected by excusing from drill those pupils who demonstrate that they possess standard ability. These pupils can spend this time upon other work.

The use of the Standard Practice Tests in ungraded schools. These Standard Practice Tests also simplify instruction in ungraded schools. In fact they save more time there than in graded schools. The same lessons are used for all pupils in Grades four to eight. Only the time allowed differs. Thus, all of the pupils in a rural school could be instructed at the same time and each pupil receive the practice which he needed.

The most important thing. However, it must not be forgotten that any set of practice exercises is merely a teaching device. It is more important that the teacher explicitly recognize in her thinking that she is instructing a group of pupils who differ widely in native ability, experience, and training, that all do not learn in the same way, and that a limitation should be placed upon training. When she ex-

plicitly recognizes these facts, the resourceful teacher will find many devices which will be helpful in adapting the instruction to the needs of the pupils.

III. Analytical Diagnosis

The need for analytical diagnosis. Diagnostic tests, and to a lesser degree general tests such as Series B, locate defects in classes and in individual pupils, but they do not tell the teacher the cause of the defect. The knowledge of the existence of the defect is very helpful to the teacher and she can proceed to eliminate it by increasing the amount of practice or by other devices as has been suggested in the preceding pages. Many cases will be corrected by such treatment, but some will not for the reason that the cause of the defect has not been removed.

The method. Whenever a pupil is found to be conspicuously below standard, the cause should be sought by "analytical diagnosis." This kind of diagnosis includes three types of procedure: (1) observing the pupil as he works; (2) studying his test papers; (3) having him do the examples orally.

Defects discovered by observing the pupil as he works under normal conditions. Courtis[1] recommends this method of diagnosis and lists seven possible symptoms for addition:

1. Child's movements very slow and deliberate, but steady.
2. Child's movements rapid, but variable. Adding accompanied by general restlessness, sighs, frowns, and other symptoms of nervous strain.
3. Child's progress up the column irregular; rapid advance at times with hesitation, or waits, at regular or irregular intervals. Often gives up and commences a column again.
4. Child stops to count on fingers, or by making dots with pencil, or to work out in its head the addition of certain figures.

[1] Courtis, S. A., *Teacher's Manual for the Standard Practice Tests* (World Book Company, 1915), pp. 16 ff.

5. Child adds each first column correctly, but misses often on second and third columns.

6. Child's time per example increases steadily or irregularly, particularly after two or three minutes' work; i.e., 15 seconds each for first five examples, 17 seconds each for the next five, 23 seconds for next two, 45 seconds for the next example, etc.

7. Child's habits apparently good and work steady, but answers wrong.

Methods of correcting these defects. Courtis recommends the following correctives for these defects:

1. Slow movements may be due either to bad habits of work or to slow nerve action. In the latter case, the difficulty will prove very hard to control. It is almost certain that no amount of training will ever alter the nerve structure and so remedy the fundamental cause. But in all such cases much can be done to generate ideals of speed, to help the child to eliminate waste motions, and to hold himself up to his best rate.

In any case the procedure would be as follows: Ask the child to add the first example alone so that you may time him. Give him the signal when to start and let him signal when he has finished. Let him make several trials of the same example to make sure that he does not improve under practice. The teacher should then give the child the watch and let him *time the teacher in working the same example.* Comment on difference in child's and teacher's times. Then have the child write in small figures all the partial sums, as shown in the illustration. The teacher should again time the child, letting him *read* to himself the partial sums as rapidly as he can. This will, of course, give the minimum time in which the child could possibly add the example. The time records of a child with true defective motor control will show slight improvement, if any, even with such aid, and probably the only procedure to follow in such cases is to lower the standard to correspond. Where there is a marked difference in time between the original and this last performance, the child will get, for the first time in its life, perhaps, a perfectly clear *conception* of what working at standard speed really means, as well as the *sensation* of really working at that speed. The teacher and child should then practice the same example over and over until the child can *without the crutches* add

$$\begin{array}{l} {}^{30}46^{15} \\ {}^{26}41\ ^{9} \\ {}^{22}97\ ^{8} \\ {}^{13}60 \\ \ \ {}^{7}61 \\ \hline \end{array}$$

it at the standard rate. Now the teacher can give him the whole test again, urging him to work at his best speed and comparing his results with the first result. The improvement made by ten minutes of this kind of work enables the teacher to say that a proper amount of similar study would produce the changes desired.

But, some teacher will say, "Will the child not learn the example by heart?" This is precisely what is desired. A perfect adder has learned so many examples "by heart" that it is impossible to make up any arrangement of figures that will be in any way new to him. The child in the same way needs to perfect his control over *each* example until he finally attains to mastery over *all.*

2. If the child gives evidence of nervous strain, check his speed, teach him to relax and to work easily and quietly. Get good habits of work first, then bring up speed and accuracy by degrees. The nervousness of a child is usually caused by social conditions, physical health, or temperamental bias. In any event, it is difficult to control. Look out for a large fatigue factor in nervous children.

3. Irregular speed up the column may be due to either of two factors: lack of control of attention, or lack of knowledge of the combinations. The latter factor will be discussed in the following paragraph (4). Attention will be considered here.

There is a limit to the length of time that a person can carry on any mental activity continuously. As time goes on, the mind tends to respond more and more readily to *any* new mental stimulus than it does to the old. The mind "wanders," as it is said. The attention span for many children is six additions, for some only three or four, for others, eight, or ten, and so on. That is, a child whose attention span is limited to six figures may add rapidly, smoothly, and accurately, for the first five figures in the column, giving its attention wholly to the work. As the limit of its attention span is reached, however, it becomes increasingly difficult for it to concentrate its attention. The child suddenly becomes conscious of its own physical fatigue, of the sights and sounds around it. The mind balks at the next addition; it may be a simple combination, as adding 2 to the partial sum, 27, held in mind. It finally becomes imperative that the child momentarily interrupt its adding activity and attend to something else. If this is done for a small fraction of a second, the mind clears and the adding activity will go on smoothly for a second group of six figures, when the inattention must be repeated.

It should be evident that these periods of inattention are critical

periods. If the sum to be held in mind is 27, there is great danger that it will be remembered as 17, 37, 26, or some other amount, as the attention returns to the work of adding. The child must, therefore, learn to "bridge" its attention spans successfully. It must learn to recognize the critical period when it occurs, consciously to divert its attention while giving its mind to remembering accurately the sum of the figures already added. This is probably best done by mechanically repeating to one's self mentally, "twenty-seven, twenty-seven, twenty-seven," or whatever the sum may be, during the whole interval of inattention. Little is known about the different methods of bridging the attention spans and it may well be that other methods would prove more effective. The use of the device suggested above, however, is common.

Giving up in the middle of a column and commencing again at the beginning is almost a certain symptom of lack of control of the attention. On the other hand, mere inaccuracy of addition (as 27 plus 2 equals 28) may be due to lack of control over the combinations. If the errors occur at more or less regular points in a column, and if, further, the combinations missed vary slightly when the column is re-added, the difficulty is pretty sure to be one of attention and not one of knowledge.

4. Hesitation in adding the next figure, when not due to attention, is usually due to lack of control of the fundamental combinations. In such cases, however, the hesitation or mistakes are usually repeated *at the same point* on subsequent additions. The teacher should understand that it "takes time to make mistakes," and whenever a lengthening of the time interval occurs, it is a symptom of a difficulty which must be found and remedied.

In this case the remedy is *not* a study of the separate combinations. It has been proved [1] that for most children time spent in study of the tables is waste effort; that the abilities generated are specific and do not transfer. A child may know 6 plus 9 perfectly, and yet not be able to add 9 to 26 in column addition except by counting on its fingers. *The combinations must be learned, of course, but they should be learned by practicing column addition.* Follow the method outlined in paragraph (1) above, having the column added over and over again until both standard speed and absolute accuracy have been attained.

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[1] See Bulletin no. 2, Department of Coöperative Research, Courtis Standard Tests, 82 Eliot Street, Detroit, Michigan. See also *Journal of Educational Psychology,* September, 1914.

5. The sums of a child who is unable to remember the numbers to be carried, but whose work is otherwise perfect, will usually have the first column added correctly, as well as all single columns. Unfortunately, however, inability to carry correctly is usually a fault of children with weak memories for partial sums in the column. It is well, therefore, to test the carrying habits of any child that is inaccurate. Many children do not add the number carried until the end of the next column; it should, of course, be added to the first figure in the column. If necessary the number to be carried should be emphasized as by saying, when the sum of a column is 27, "carry 2" to one's self as the 7 is written. This is again a time-consuming device which should be adopted only as a last resort. The carrying should be an automatic, unconscious operation. Repeated practice on a few examples until the same become so perfectly familiar that a child's whole attention may be given to establishing correct habits of carrying will prove beneficial.

6. Marked increases in the times required for the successive examples of a test are an indication of a fatigue factor in the control of the attention. Some children are unable to carry on continuously a single activity, as adding, through even a four-minute time interval without a very great loss in power. Two courses are open to the teacher, one or the other of which is sometimes effective: one is to determine the exact length of the interval at which the child can work efficiently, and then try to extend the interval slightly each day; the other is to set the child at work on very long and very hard examples, and to lengthen the time intervals to fifteen or twenty minutes' continuous work. Difficulties of this type are hard to remedy.

Errors discovered by examining test papers. This method of diagnosis cannot always be used because some examples, e.g., the addition test of Series B, are such that the nature of the pupil's errors cannot be determined from his work. However, in common fractions and to a certain extent in subtraction, multiplication, and division of integers, the nature of the errors can be determined.

An illustration of errors made on Series B. Gist[1] exam-

[1] Gist, Arthur S., "Errors in the Fundamentals of Arithmetic"; in *School and Society* (August 11, 1917), vol. 6, p. 175.

ined 812 papers of the Courtis Standard Research Tests, Series B, chosen at random from six schools in Seattle. The frequency, reduced to a per cent basis of each type of error for subtraction, multiplication, and division in the respective grades, is shown in Table XVII. In subtraction "omissions" refer to the number of pairs of digits omitted altogether. Reversions occur when 9 should have been taken from 8, but the digits were reversed. The error indicated by 7–0, is only typical of many similar mistakes when a cipher occurs. The left-hand digit caused some trouble in the eighth grade. In the example:

```
107795491
 77197029
---------
129598462
```

the left-hand digit was carried down, as shown.

TABLE XVII. FREQUENCY OF TYPES OF ERRORS IN SUBTRACTION, MULTIPLICATION, AND DIVISION, BASED UPON A STUDY OF 812 TEST PAPERS, COURTIS'S STANDARD RESEARCH TESTS, SERIES B. (GIST.)

	4th	5th	6th	7th	8th
Subtraction:					
Borrowing	54	56	52	51	55
Combinations	36	38	45	44	41
Omissions	2	1	2	3	1
Reversions	1	2	1/2	0	0
7–0, etc.	5	3	1/2	0	0
Left-hand digit	0	0	0	0	2
Multiplication:					
Tables	79	73	73	77	75
Addition	18	20	22	19	20
Cipher in the multiplier	1.5	6	5	4	5
Division:					
Remainder too large	34	39	27	19	10
Multiplication	22	15	19	37	38
Subtraction	11	14	18	25	23
Last remainder 0 and 0 in the dividend	7	15	19	7	11
Multiplicand larger than the dividend	7	4	1	1	1
Failure to bring down all of the dividend	7	4	3	0	6
Failure to bring down correct digit	2	1	4	4	6
Failure to place all of quotient in quotient	7	1	1	3	3
Cipher in quotient as 908–98	3	7	8	4	7

Errors in adding common fractions. The errors which pupils make in the addition of two fractions have been studied so that we know what types are most likely to occur. (1) Counts[1] found in a study of tests given to eighth-grade pupils that sixty per cent of the errors were due to adding the numerators for a new numerator and also adding the denominators for a new denominator, as $3/5 + 1/5 = 4/10$, or $1/9 + 5/9 = 6/18$. It will be noticed that these examples constitute one of the simplest cases in addition of fractions. (2) Twenty-seven per cent of the errors were due to multiplying the numerators for a numerator and multiplying the denominators for a new denominator; as $3/5 + 1/5 = 3/25$, or $1/9 + 5/9 = 5/81$. (3) In a test where it was necessary to reduce the sum to the lowest terms and to a mixed number, Kallom[2] found that nineteen per cent failed to reduce the result to a mixed number and eighteen per cent failed to reduce it to its lowest terms. About half of these pupils failed to make either reduction. About one pupil in twenty failed to express the result correctly when reducing a fraction to its lowest terms, writing $20/15 = 1\ 5/15 = 1/3$, instead of $1\ 5/15 = 1\ 1/3$. (4) Kallom also found certain methods of addition which waste the pupil's time and tend to introduce errors:

Approximately *one third* found it necessary to reduce the fractions to a common denominator in the first test when the fractions were already similar. Some of these children wrote the fractions over a common denominator, using for a common denominator the denominator of the similar fractions. Others, not noticing that the fractions already had a common denominator, used some multiple,

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[1] Counts, George S., *Arithmetic Tests and Studies in the Psychology of Arithmetic* (Supplementary Educational Monographs, no 4, University of Chicago Press), p. 65.

[2] Boston Document no. 3. (1916.) *Arithmetic; Determining the Achievement of Pupils in the Addition of Fractions.* Bulletin no. 7 of the Department of Educational Investigation and Research, p. 19.

making necessary reductions. For example, many children added 3/14 and 1/14 by reducing the fractions to a common denominator of 196. In many cases they then made errors in their work, thus obtaining an incorrect answer to the example. Even if carried through correctly, this is an ineffective and wasteful way of doing such examples.

Another method used by many individuals consisted of finding the least common denominator of such fractions as 1/8 and 3/16 by finding the least common multiple of the denominators by short division as taught in many of the arithmetics. In such cases the following was found:

$$\begin{array}{r|l} 2 & 8 - 16 \\ 2 & 4 - 8 \\ 2 & 2 - 4 \\ 2 & 1 - 2 \\ & 1 - 1 \end{array} \qquad 2 \times 2 \times 2 \times 2 = 16$$

Errors in subtracting common fractions. Counts found two errors which occurred very frequently in subtracting fractions having like denominators. (1) Numerators subtracted for the new numerator and the denominators subtracted for the denominator as $6/9 - 4/9 = 2/0$, or $3/7 - 1/7 = 2/0$. (2) Numerators multiplied for the new numerator and the denominators multiplied for the denominator as $6/9 - 4/9 = 24/81$, or $3/7 - 1/7 = 3/49$. A considerable number of pupils added when subtraction was indicated by a minus sign. This may have been due in part to the fact that both addition and subtraction were included in the same test, but the writer has found similar errors when the two operations were in separate tests.

Correctives for these errors. The first essential for the correction of a defect in a pupil is the knowledge of its existence and nature. Without this knowledge attempts to correct it must be a random trying of methods and devices in hopes that some one will meet the need. Frequently the teacher who knows just what defects exist will be acquainted

with some method or device which will serve as an effective corrective. If he is not, a knowledge of the laws of habit formation, which is the type of learning involved in the operations of arithmetic, will help.

The laws of habit formation. Stated in psychological terms, the *first law* is that in the beginning the attention of the learner shall be focalized upon the habit to be acquired. In terms of schoolroom practice this means that the learner shall understand what reaction is to be made to a given stimulus, and shall then react to it in the appropriate manner. This gives the learner the right start.

The second law is that the accomplishment of the step outlined in the first law shall be followed by attentive repetitions. It is not sufficient that there be simply repetitions or drill. The drill must be attentive. In the case of the operations of arithmetic this drill may be detached from the solving of problems, or it may be given in the solving of problems.

The third law states that no exception shall be permitted until the habit is firmly established, which means that the attentive practice must be continued until the operation has become a habit; that is, has been made automatic.

"Borrowing." Table XVI shows that, for the pupils of Seattle, "borrowing" is the most frequent error in subtraction. Some teachers insist that this error can be corrected by using the Austrian or additive method of subtraction instead of the traditional or "take away" method. Although we do not have enough information in order to be able to say positively which method is superior, it appears that the "take away" method is superior to the Austrian method. The latter method may be helpful to certain pupils who have difficulty with subtraction. There are two types of errors in connection with "borrowing." (1) A pupil may fail to "borrow" when he should. (2) "Borrowing" may become a

mechanical feature of subtracting and the pupil will "borrow" when the example does not require it. In the first case the pupil must be taught to "borrow." If he has difficulty in grasping the idea, the additive or Austrian method may be presented. It may be that the first law of habit formation has been fulfilled and the pupil needs "attentive repetition" or drill. It will also be helpful to have the pupil do an example several times before proceeding to another. In the second case it will be helpful to give some examples in which no "borrowing" is required. This will demonstrate to the pupil that "borrowing" does not always occur in subtraction.

Combinations or tables. Errors in combinations were next to "borrowing" in frequency, and errors in tables stand at the top of the list in multiplication. Such errors may occur because the pupil does not know certain combinations or because he does not know them well enough. That is, the defect may occur in either the first or second law of habit formation. A few pupils have great difficulty in learning certain combinations. When this is known to be the case, these combinations should be singled out and be made a matter of special drill. Generally when errors in the tables occur in the fourth grade and above, the combinations should not be practiced upon separately, but as they occur in examples. The situation is the same as in addition. (See page 141.)

Remainder too large in division. Outside of errors in multiplication and subtraction this is the most frequent error in division. This error, as well as most of the other errors listed for division, is due to an imperfect plan of procedure; that is, to the failure to apply simple checks at certain steps of the work. The process of division is peculiar in that it is possible to avoid most errors by applying simple checks at certain stages of the work, and pupils should be definitely taught to do this. It is very simple to note whether

the remainder is too large by comparing it with the divisor, and this comparison should be taught as a regular step of division.

Failure to reduce sum in addition of fractions. This error is also due to an imperfect routine. Pupils should be taught that the reduction of the answer to a mixed number and to lowest terms is always a part of the work when possible. These errors can be corrected in most cases by the teacher insisting that the reduction be made and providing practice in doing it. Practice upon reduction apart from addition will not be as effective as practice on it as a part of addition. It is a good plan to give no credit for work which is not complete, for the third law of habit formation, permit no exceptions, applies here.

Incorrect methods in handling fractions. Doing such things as adding the denominators when adding fractions is due to the pupil having not fixed the procedure for addition. To correct such defects, the pupil should be shown the correct procedure and drilled upon it. This drill should at first be upon only one type of example, but later lists of mixed types should be used. Here is a good opportunity to use lists written on cards which may be distributed. This makes it convenient to time the pupils, and this is very important because it requires the pupil to decide quickly upon the method to use.

Time-wasting methods. Kallom (p. 144) reports a number of pupils using methods which require more time than is necessary. This will be corrected to a large extent by the teacher emphasizing the rate of work as being important. Of course, it is more important that a pupil have his work correct than to work rapidly, but frequently it is helpful to emphasize the rate of work.

Analytical diagnosis by the oral method. By having a pupil do examples orally, it is possible to discover (1) par-

ticular errors in the combinations and (2) imperfect and wasteful methods.

Illustrations of wasteful methods. By using this method of diagnosis the writer has found that in addition many pupils repeat each number to be added. For example they say, "7 and 6 are 13 and 5 are 18 and 4 are 22 and 5 are 27," instead of simply calling the partial sums, as "13, 18, 22, 27." Similar elaborate phraseology is used in the other operations. No error is involved in this method, but it consumes time.

Uhl's oral diagnosis of errors. Using Lesson 1 of the Courtis Standard Practice Tests, which consists of single-column addition, three figures to the column, Uhl[1] studied the errors of pupils by having them do the examples orally and by asking them detailed questions when their method was not made clear. To illustrate the method and also the nature of the defects revealed we quote from his report:

> The findings as to methods employed by pupils in "difficult" combinations is both interesting and significant. The following methods were found in the work of pupils who were tried out in the manner just described. A fourth-grade boy showed by slow work that the combination 9–7–5 was difficult for him. When questioned, he showed that he used a common form of "breaking-up" the larger digits. In working the problem, he said to himself: "9 + 2 + 2 + 2 + 1 = 16 and 21." This shows that the 9–7 combination was not known, but that the 16–5 combination was, inasmuch as he arrived at "21" directly after having combined the other two numbers. Another boy of the same grade showed the same type of difficulty in a more pronounced form. He added 8, 6, and 0 as follows: "First take 4, then take 2, then add 8 and 4 makes 12, and 2 makes 14." In adding 9, 7, and 5 he said: "9 and 3 is 12 and 4 is 16 and 2–18; and 2–20; and 1–21." He broke into parts even so easy a problem as 3 + 4 + 9, adding 9 + 3 + 2 + 2 = 16.

[1] Uhl, W. L., "The Use of Standardized Materials in Arithmetic for Diagnosing Pupils' Methods of Work"; in *Elementary School Journal* (November, 1917), vol. 18, p. 215.

A pupil from the fifth grade presented a quite different method of adding. In adding 4, 9, and 6 she explained: "Take the 6, then add 3 out of the 4. Then 9 and 9 are 18, and 1 are 19." Other problems were worked out similarly: one containing 3, 9, and 8 was solved as follows: "8 and 8 are 16 and 3 are 19 and 1 are 20"; 5, 6, and 9 as follows: "6, 7, 8, 9, and 9 are 18 and 2 are 20." This tendency to build up combinations of 8's or 9's continued in the case of another problem: 6, 5, and 8 were added thus: "6, 7, 8, and 8 are 16 and 3 are 19." Probably her first problem was worked similarly, but I had to have her dictate her method twice before I understood; she then gave it as quoted.

Methods which are quite as clumsy are found in the case of subtraction. One boy of the fifth grade was found to build up his subtrahend in the case of many problems. For example, in subtracting 8 from 37, he increased his subtrahend to 10, then obtained 27, and finally added 2 to 27 to compensate for the addition of 2 to 8. Likewise, in subtracting 7 from 30, he added 3 to 7 and proceeded as before. This boy knew certain combinations very well, but did problems containing other combinations by a method much harder than the correct one.

Even greater resourcefulness was shown by a fifth-grade boy who found the differences between some numbers by first dividing, then noting the remainder or lack of one, then multiplying, and finally adding to or taking from the result as necessary. For example, in subtracting 9 from 44, he proceeded as follows: "Nine goes into 44 five times and 1 less; 4 times 9 are 36, minus 1 equals 35." That is, this boy knew certain multiplication combinations better than he did certain subtraction processes; therefore, he used multiplication, making adjustments either upward or downward as demanded by the problem.

The Remedy. Where a pupil simply uses an elaborate phraseology he should be trained to use a simplified method. The plan of timing the pupil and then having the pupil time the teacher, or comparing his rate with the standard rate, will show him that his method is slow. The use of such methods as described above in the earlier grades may be justified, but teachers should make certain that they are replaced by more efficient ones later. It will help to recog-

nize the rate of work as an important "dimension" of the ability to do examples. When a pupil is found who does not know certain combinations, but is doing the examples by an ingenious method of counting, he must be taught these combinations.

An illustration of corrective instruction. A fifth-grade class [1] was given the Cleveland Survey Tests [2] to determine the types of examples which the pupils could not do with standard ability. This information was supplemented by oral diagnosis in correcting the defects revealed. The regular "class instruction was supplemented at other periods in the day by special help to different pupils in the processes in which they were weak, and they were required to work extra examples in those processes after the help had been given. The drill was limited to the four fundamental operations with integers and fractions. At the end of a month of this kind of instruction, the pupils were given the original test a second time."

In Fig. 27 the record of one pupil, who made some very low scores on the first test, is shown. The figure is so drawn that if the pupil were just up to standard in each test (A, B, C, D, etc.), the line representing his record would be a straight horizontal line. The solid line represents his first record and the broken one his second record. Corrective work was attempted in Tests A, B, F, I, N, and O, and the figure shows a marked improvement was made in these tests. By planning the corrective instruction more carefully it is probable that a still more uniform development might have been obtained. However, as it is we have a striking illustration of what can be accomplished when a diag-

[1] Smith, James H., "Individual Variations in Arithmetic"; in *Elementary School Journal* (November, 1916), vol. 17, p. 198.

[2] These tests are similar to Monroe's Diagnostic Tests except that they contain no tests on decimal fractions.

nosis of a pupil is made and the instruction is based upon the diagnosis.

Summary. In this chapter we have considered the causes of and corrections for the following types of class scores; (1) below standard in both rate and accuracy; (2) below stand-
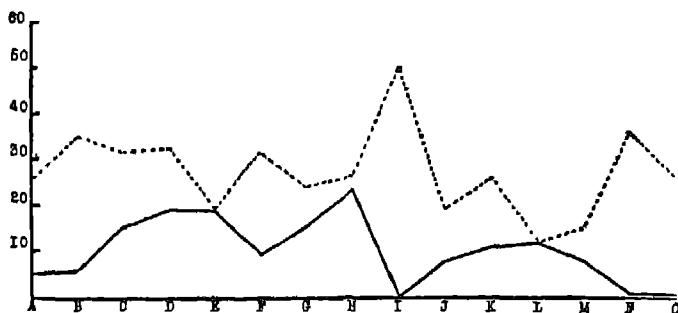
FIG. 27. SHOWING TWO RECORDS OF ONE PUPIL ON THE CLEVELAND SURVEY TESTS.

First record, solid line. Second record, four weeks later; dotted line, corrective work given on Tests A, B, F, I, N, and O.

ard in rate with satisfactory accuracy; (3) below standard in accuracy with satisfactory or high rate; (4) scores too widely scattered; (5) irregular development. In connection with the case of irregular development the value of diagnostic tests was pointed out. In dealing with individual pupils who are below standard analytical diagnosis is helpful for discovering the cause of the defect. Several illustrations of this method of diagnosis have been given together with the correctives for handling each case.

QUESTIONS AND TOPICS FOR STUDY

1. Do you think pupils will welcome detailed objective standards and the use of standardized tests? Why?
2. If you are using standardized tests make charts showing class (or individual) scores in comparison with the standards. Some teachers

have found it helpful to have such charts hung in the classroom. It is also helpful to bring such charts to the attention of the patrons of the school.

3. Make a chart showing how the pupils of your class compare with other classes of the same grade and with classes of other grades
4. Suppose a pupil is unable to do satisfactorily certain types of examples. How would you proceed to locate his particular difficulties? If you are teaching arithmetic, try out your plan on some of your pupils.
5. What device do you use to provide each pupil with the training which he needs? What devices are suggested in this chapter? Can you suggest additional ones?
6. Pupils who are excused from drill because they do not need it should spend their time doing profitable things. Suggest a number of assignments which might be made to such pupils. The assignments may be in subjects other than arithmetic if it seems wise, but they should be such as not to interfere with the instruction of the other pupils.
7. How do you know that the methods and devices of instruction which you are now using are the best? How could you find out?
8. How do you know that you are not giving too much time to arithmetic? How could you find out?
9. Is a class score which is conspicuously above standard a sign of superior teaching? Why?
10. Construct two tests, each being confined to a single type of example. Give both tests to the same pupils under the same conditions. Compare the two sets of scores.
11. Scientific experimentation will be necessary to determine the best plans of grouping pupils for instruction. These plans are worthy of a trial.
    a. In a building place together for drill those pupils which are most nearly equal in ability as shown by the tests.
    b. Excuse from drill those who have demonstrated that they are above standard.
    c. Have a special "hospital" class for those pupils who have scores conspicuously below standard. A pupil's sentence to the "hospital" would be until he brought his scores up to standard.

CHAPTER VI

THE MEASUREMENT OF ABILITY TO SOLVE PROBLEMS AND CORRECTIVE INSTRUCTION

Description of Monroe's Standardized Reasoning Tests. The measurement of the ability of pupils to solve problems requires a list of problems whose difficulty or value has been determined, because we saw in Chapter I that problems are not equally difficult. Monroe's Standardized Reasoning Tests consist of a series of three tests: Test I for the fourth and fifth grades, Test II for the sixth and seventh grades, and Test III for the eighth grade. Two forms of each test are available so that when it is desired to test the pupils a second or third time, it is not necessary to use the same list of problems. Each problem has been given to several hundred pupils and its value has been determined both for correct principle and for correct answer. Thus, each problem has two values, one a "principle value," which represents the credit to be given for correct reasoning in solving it, and the other a "correct answer value," which represents the credit given for making the calculations correctly when the problem has been worked according to the correct principle.

An important feature of these tests is the manner in which the problems were selected. The writer believes that a satisfactory reasoning test must be composed of problems which are representative in language and content. In order to secure such a list the one- and two-step problems in eight widely used textbooks, which totaled about nine thousand problems, were collected and classified according to the language in which they were stated. The necessity for this

classification will be taken up later under the head of "Diagnosis." The types of problems used in the tests occurred in at least five of the eight textbooks, which insures that the language of the problems is representative of that used by the authors of our textbooks.

The tests are printed so that the pupil has space to do each problem on the test paper beside the printed statement of it. This eliminates the necessity of copying either the problem or the work. Thus, the teacher has a complete record of the pupil's work which is valuable for making an analytical diagnosis. The following problems will illustrate the nature of the tests:

Problem	Values
A farmer raised 500 bushels of wheat on a field of 40 acres. What was the average yield per acre?	Principle value 2 Answer value 2
A tailor uses $9\frac{3}{4}$ yds. of cloth for a suit. How many yards will it take for 32 suits?	Principle value 1 Answer value 2
A field is 20 rods long, and 12 rods wide. How many rods of fence are needed to enclose it?	Principle value 2 Answer value 1
How much more is earned per day by a man receiving $30 per week than by a man earning $18 per week?	Principle value 3 Answer value 2

Method of giving the tests. Detailed instructions for giving the tests are printed on the test sheets and thus need not be repeated here. One point, perhaps, should be explained. In the case of silent reading and the operations of arithmetic, we have emphasized the fact that ability was "two-dimensional"; that is, that the rate was important as well as the comprehension or accuracy. In solving a problem, the relative importance of rate as a "dimension" of the ability is less, but probably should not be neglected. Ac-

cordingly the directions for giving the tests require the pupil to mark the problem which he is working on at the end of a given number of minutes and then he is allowed to finish the test. This gives a rate score and also a score independent of the rate of work.

Scoring the test papers. Instructions for scoring the papers are furnished with the tests, but certain points should be noted here. In order that the "ability to reason" may be measured separately from the "ability to perform operations," each problem is marked for both "correct principle" and "correct answer." A solution is marked correct in principle when it shows that the pupil has reasoned correctly. If a pupil fails to remember correctly some fact, such as the number of pounds in a bushel of wheat or the number of square feet in a square yard, his reasoning is not affected. An answer is counted as correct when (1) the solution is correct in principle and (2) also the answer is numerically correct and in its lowest terms.

Each pupil is given three scores: (1) "Rate of reasoning," which is the sum of the "principle values" of the problems solved within the time limit allowed. (2) "Correct reasoning," which is the sum of the "principle values" of all the problems solved correctly in principle. (3) "Correct answer," which is the sum of the "correct answer values" of those problems which were solved correctly in principle and for which the correct answer was obtained.

Recording the scores. The class record sheet is similar to that used for Monroe's Standardized Silent Reading Tests. A blank for recording the third score is provided. This record sheet and detailed instructions for recording the scores are furnished with the tests. The median scores of the class may be calculated either by the directions given for the Standardized Silent Reading Tests on page 29, or by the directions for Series B on page 104.

Standards. These tests have been used only in a preliminary form, and for this reason standards have not yet been announced. However, standards will be determined as soon as reports have been received from a sufficient number of schools, and any one who is interested may obtain them by writing the Bureau of Educational Research, University of Illinois, Urbana, Illinois.

Interpretation of class records. Because the final form of these reasoning tests has not been used, it is not possible to give typical class records upon which to base this discussion of the interpretation of scores. However, the preliminary form was given to over thirteen thousand pupils, and upon the basis of these results types of situations which require correction can be predicted with a high degree of certainty: Type I, low median score for "Rate of reasoning"; Type II, low median score in "correct reasoning"; Type III, low median score in "correct answer" indicating inaccurate calculation; Type IV, scores too widely scattered or distributed.

Type I. Median score for "rate of reasoning" below standard. From the nature of the test it is obvious that the rate of reasoning is not measured separately from the rate of calculation, for a pupil not only "reasons out" a problem, but also performs the necessary operations before he proceeds to the next one. Hence, the "rate of reasoning" score is a measure of the rate of reasoning plus the rate of calculation. For this reason a score may be below standard either because the pupil was slow in his reasoning or because he was slow in performing the operations. This fact must be kept in mind in interpreting this type.

In the preliminary test some classes worked much more slowly than others, apparently because they had not formed the habit of working rapidly. This was probably due to the teacher failing to recognize the rate of work as important. The writer does not believe the rate of work is as important

in solving problems as in performing the operations of arithmetic, but it is his judgment that the rate of reasoning should not be neglected. The teacher should at least occasionally time pupils when they are solving problems, telling them, however, that it is more important to have their work right than to solve a large number of problems.

Stone[1] tells of the case of one pupil who had not learned how to work rapidly:

Pupil, H. C.

Diagnosis: Up to standard in reading ability, did not indulge in undue labeling, physical examination showed no defects, constantly made low scores. Conclusion as to cause of low score: *Mental laziness with lack of realization of the passing of time.*

Treatment: The pupil was first of all made conscious of his status by comparing his score with those of his fellow classmates and with the standard; then he was helped to study his way of working which convinced him of the seat of his difficulty. From day to day lists of approximately equivalent problems were given him with time limit. Much was made of record of scores, gain being expected by both teacher and pupil.

Results: Within a few days notable gain appeared, due to increased ability to direct and hold attention to the work in hand. Contrasted with his previous tendency to wander, the pupil became capable of working continuously in spite of such distractions as people entering the room. After about twenty minutes daily for three weeks he raised his score from 4 to 5.4.[2] Though this is not a large gain in score, the boy had made it largely of his own initiative; he had formed an ideal of concentration, and the concept of *giving attention* to reasoning processes was well under way. It is believed by those who have studied the boy that much of his improvement was due to the convincingness of the objective evidence of his need to improve.

Some pupils worked slowly because apparently they did not know how to think out the plan of solution. They would

[1] Stone, C. W., *Standardized Reasoning Tests in Arithmetic and How to Utilize Them.* Teachers College (1916), p. 23.

[2] These scores refer to Stone's Reasoning Tests.

try one plan and then erase their work or cross it out and try another plan. In such a case the pupils need to be taught how to think. This situation occurs more frequently with individual pupils than with whole classes, and for that reason the corrective measures will be discussed under that head.

A low median score, due to slowness in performing the operations, may occur in two ways. First, the pupils may not be trained to perform the operations rapidly. This can be verified by giving a test upon the operations such as Series B. If their scores on these tests are below standard in rate, the correctives given on page 123 should be applied. Second, the pupils may be recording their work in some particular form which the teacher requires. The pupils in some classes write out the solution in the form of an analysis or record in other ways which consume time. Orderliness and system are desirable. In a reasonable degree they are necessary, especially when the solution of a problem is long. But it should always be remembered that they are a means or method for making the solution of the problem easier. The teacher should not insist upon a particular form or system when it interferes with the pupil's work.

An illustration of low rate of work due to this last cause and the effect of corrective treatment is given by Stone:[1]

Some pupils of a certain fifth grade

Diagnosis: Many pupils made very low scores, many papers much covered with such statements as, "If one tablet cost 7 cents, 2 tablets . . . etc." Here was evidently one large source of failure.

Treatment: Emphasis was placed on the possibility of saving time by not writing so much, brief labels were devised, originality was encouraged, and approval of pupils and teacher placed on briefest adequate statement.

[1] Stone, C. W., *Standardized Reasoning Tests in Arithmetic and How to Utilize Them.* Teachers College (1916), p. 23.

Results: As shown by second test and by daily work, much time was saved for reasoning processes. The following parallel columns show typical results:

Pupil, A. K.

In first test	*In second test*
They would cost \$18. If one suit cost \$2.50, 9 would cost \$2.50 × 9 = \$22.50. They would cost \$40.50.	\$2.50 × 9 = \$22.50 \$2.00 × 9 = \$18. \$40.50
Score in first test, 1 1/3.	Score in second test, 3.

Pupil, L. I. C.

In first test	*In second test*
If he sold 4 papers and got twenty cents for them, one half would be 10 cents, and with the other 10 cents he bought Sunday papers, he would buy as many as 2 will go into 10 or 2)10 5 papers.	5 4 20 One half would be 10 cents and he could buy five.
Score in first test, 3.	Score in second test, 4 1/2.

Type II. Below standard in correct reasoning. In order to understand the reasons for a class being below standard in reasoning and the corrective measures which should be used, it is necessary to understand just what is required of the pupil in solving a problem. The process of solving a problem by reflective thinking may be described in the following steps:

1. It is necessary that the pupil read the statement of the problem with understanding. This is a complex process and involves several abilities: eye-movement, perception, association of meaning with symbols, and combining the several elements of meaning into an understanding of the problem. Out of this should come a definition of the problem, which

is the *first step in reflective thinking.* It should be noted that two kinds of words occur in the statement of problems; *first,* words which describe the setting of the problem or the particular environment in which it occurs, and *second,* words which define quantities or quantitative relationships. This second class of words we may call *technical.* The meanings associated with them must be exact. Take, for example, this problem, "What is the value of sugar obtained at a Vermont sugar camp if it is worth ten cents per pound and six pounds are obtained on an average from each of 1275 maple trees?" Words in this problem such as "Vermont," "sugar," "maple," and "camp" describe the setting. They have nothing to do with the solution of the problem. The technical words are such as "value," "per pound," "are obtained," and "each." They define the relationships which exist between the quantities and are cues for formulating the hypothesis or plan of solution which is another step in the process.

2. Principles applicable to the problem must be recalled. For example, in the problem, "A man invests $893 in some property. He sells the property for $1050. What is his rate of profit?" it is necessary to recall the principle that the rate of profit is calculated upon the amount invested and not upon the selling price. The principles and the meanings of the technical words are the *data or facts which are used in the reflective thinking.*

3. The elements of meaning and the recalled principles are used in formulating a plan of procedure or *hypothesis* concerning the operations to be performed upon the quantities of the problem. In doing this each element of meaning must be given its proper weight. A relatively inconspicuous term may require an operation. For example, in the problem, "A rectangular court 72 feet by 120 feet is to be paved at a cost of $2 per square yard. What will be the ex-

pense?" the use of "square yard" instead of "square foot" in the statement of the problem makes necessary an additional operation.

4. The hypothesis thus formed should be *verified*. Generally this does not occur as an explicit step. It consists of seeing that the hypothesis is in agreement with the several elements of meaning and the recalled principles.

5. The operations outlined in the hypothesis are performed. Strictly speaking, *this is not a step in the reasoning process*. This is completed when a correct plan of action is formulated.

This analysis assumes that the problem is solved by *reflective* thinking. In many cases the pupil does not reflect. If it is very familiar he may automatically identify it as requiring a particular operation or operations. This may happen after only a partial reading of the problem. Under any circumstances this procedure is probably more of the nature of a "short-circuiting" of the reflecting thinking process than an exception to it. When the problem is unfamiliar the pupil may try random guessing at the plan of solution.

It was noted that the data used in solving a problem come from two sources, recalled principles and the meanings of the technical words used in the statement. The ability to associate the correct meaning with one term does not imply the ability to associate the correct meaning with another term. The ability to solve the problem, "At $55 each how much must a farmer pay for 25 cows?" does not make certain the possession of the ability to solve "Find the duty on $600 worth of clocks at 40% *ad valorem*," although the same operation is required. The technical terms, such as "$55 each," "pay for," "find the duty," and "*ad valorem*," are sufficiently different so that a pupil might know the meaning of one set without knowing the meaning of the other. The meaning of the technical terms in a problem furnishes

important data or cues for the judgment concerning the operations to be performed. In many cases it appears that the determining data come from this source. Thus, in measuring a pupil's ability to solve printed problems we are measuring his knowledge of technical terms as well as his ability to use this knowledge in formulating plans of procedure.

The reading of problems is difficult because many forms of statement are used. The solving of a problem requires a careful reading of it with a high degree of understanding and such reading of problems is a more complex and difficult task than we commonly realize. Problems are stated in many forms and the total "technical" vocabulary which is required of a pupil by the time he completes the work of the elementary school is a large one. For an illustration, take this problem situation: Given $7.50 paid for silk and price per yard $1.50, to find number of yards purchased. Excluding different arrangements of the words used, twenty-eight different forms of statement were found in examining eight textbooks for describing this problem situation, and additional forms could be constructed.

1. How many yards of silk at $1.50 per yard can be bought for $7.50?
2. The silk for a dress cost $7.50. How many yards were purchased at $1.50 per yard?
3. At $1.50 per yard, how many yards of silk does a woman get if the amount of the purchase is $7.50?
4. At the rate of $1.50 per yard my bill for silk was $7.50. How many yards were purchased?
5. How many yards of silk at $1.50 a yard does a bill of $7.50 represent?
6. When silk is $1.50 a yard, a piece of silk costs $7.50. How many yards in the piece?
7. At $1.50 a yard how many yards of silk does a merchant sell if he receives $7.50 for the piece?
8. Mrs. Jones purchased silk at $1.50 a yard. The entire amount paid was $7.50. How many yards were bought?

9. Silk was sold at $1.50 per yard. A check for $7.50 was given in settlement. Find the number of yards bought.
10. At $1.50 per yard, how many yards can be bought for $7.50?
11. A merchant sells a number of yards of silk for $7.50. The price being $1.50 for each yard, how many does he sell?
12. I invested $7.50 in silk at $1.50 per yard. How many yards did I buy?
13. When silk is $1.50 per yard, how many yards can be bought for $7.50?
14. When silk is sold for $1.50 for each yard, what quantity can be bought for $7.50?
15. At the rate of $1.50 per yard, how many yards can be bought for $7.50?
16. Silk is selling for $1.50 per yard, how many yards should be sold for $7.50?
17. At a cost of $1.50 a yard, how many yards can be bought for $7.50?
18. Silk was bought at a cost of $1.50 per yard. At that rate, how many yards can be bought for $7.50?
19. At $1.50 a yard a piece of silk cost $7.50. How many yards in the piece?
20. How many yards of silk at $1.50 can I buy for $7.50?
21. $7.50 was paid for silk at $1.50 per yard. How many yards were bought?
22. Find the number of yards; cost $7.50. Price per yard $1.50.
23. The cost of a piece of cloth is $7.50 and the cost per yard is $1.50. How many yards are there in the piece?
24. A woman paid $7.50 for a piece of silk that cost her $1.50 per yard. How many yards were there in the piece?
25. A woman had $7.50 and bought silk at $1.50 a yard. How many yards did she buy?
26. A quantity of silk at $1.50 per yard cost $7.50. What was the quantity?
27. Silk is $1.50 a yard and I bought $7.50 worth to-day. How many yards did I buy?
28. A woman's bill for silk was $7.50. If each yard cost $1.50, how many yards were bought?

This illustration of the variety of terms which are used in the statement of one problem becomes more significant

when we remember that this is just one problem and a relatively simple one. It should be clear that learning to read problems is not an easy matter.

A test to measure a pupil's knowledge of words used in problems. The test given below was devised to measure a pupil's knowledge of the meaning of words used in stating problems. The words in this test were found to be "common" to three or four of the newer textbooks for the grades in which the test was given. A preliminary test was given first to insure that the pupils would understand what the test asked them to do.

VOCABULARY TEST IN ARITHMETIC [1]

Name...................... Grade ....

1. Put *w* beside each word that tells what a man's work is.
2. Put *m* beside each word about money.
3. Put *l* beside each word that might be used about land.
4. Put *i* beside each word that is the name of something to put things in.

basin	area	merchant	profit
salary	carpenter	cashier	pasture
retail	field	building lot	earn
mason	bin	attend	collect
basket	real estate	teamster	tank
lot	poultry	jars	acre
bucket	fares	debts	income
rent	dealer	gardener	insurance
machinist	tailor	expenses	miller
coins	barrel	nickel	cistern
broker	wages	owe	customer
excavate	commission	schedule	

In Table XVIII the per cent of pupils in both the fourth and fifth grades who failed to mark the words correctly is given. Thus, forty per cent of fourth-grade pupils and

[1] Chase, Sara E., "Waste in Arithmetic," *Teachers College Record* (September, 1917), vol. 18, p. 364.

TABLE XVIII. SHOWING PER CENT OF FAILURES ON VOCABULARY TEST IN ARITHMETIC

	Grade			Grade	
	IV	V		IV	V
basin	26%	20%	merchant	45%	24%
salary	40	20	cashier	52	20
retail	30	16	building lot	65	32
mason	78	36	attend	4	4
basket	13	8	teamster	88	40
lot	9	12	jars	40	16
bucket	30	16	debts	91	32
rent	56	28	gardener	17	8
machinist	35	28	expenses	65	20
coins	26	16	nickel	13	16
broker	56	45	owe	91	60
excavate	4	4	schedule	17	4
area	91	36	profit	78	45
carpenter	26	8	pasture	52	32
field	9	8	earn	60	36
bin	43	20	collect	17	8
real estate	100	68	tank	65	36
poultry	40	36	acre	56	32
fares	65	60	income	96	41
dealer	35	28	insurance	91	42
tailor	13	4	miller	26	12
barrel	30	32	cistern	100	88
wages	70	28	customer	35	44
commission	100	68			

twenty per cent of fifth-grade pupils failed to mark "salary" as a "word about money." All of the words in this list are not technical terms, but a number, such as "salary," "rent," "area," "field," and "bin," are used in designating the relationship of quantities in problems. For example, "A man receives $185 per month. What is his yearly salary?" or, "A house rents for $40 per month. How much is that a year?" In the first problem a pupil cannot reason about the situation unless he knows that "salary" refers to the "$185 per month" which the man receives.

In another test pupils were asked to draw the figures named in Table XIX. The numbers in the table are the per cent of pupils in each grade who failed to draw the correct figure.

TABLE XIX. SHOWING PER CENT OF PUPILS WHO FAILED TO DRAW CORRECTLY THE FIGURES NAMED

	Grades		
	III	IV	V
Square	10	4	8
Rectangle	100	39	80
Triangle	50	35	20
Oblong	15	40	4
Rectangular plot		87	68

These two simple tests show something of what the situation in arithmetic probably is. We are asking pupils to solve problems when they do not know the meaning of the terms used in the problems. We must, therefore, begin to give explicit instruction in the meaning of technical terms.

When a class is below standard in correct reasoning, one of two conditions exists. First is a case of ignorance; the pupils do not know the meaning of the technical terms or cannot recall the required principles and facts. The second may be the lack of knowing how to use this information or the lack of a sufficient motive. After examining the test papers of several thousand pupils, it is the writer's judgment that the first is the more frequent condition, but often pupils fail to reason correctly in solving problems because they have no plan of thinking. We saw in the case of silent reading that one cause of poor comprehension was the fail-

ure to verify the meaning obtained. In solving problems pupils "accept" an incorrect solution because they do not verify their plan; that is, they omit the fourth step in the process as outlined on page 162.

The general correctives are suggested by the above analysis. The pupils should be taught the arithmetical meaning of the technical terms used in stating problems. They should also be trained to have a good procedure, to be somewhat systematic in their reasoning. Especially should emphasis be placed upon the step of verification.

Type III. Below standard in calculation. These tests were not designed to measure ability to perform the operations of arithmetic. For this reason too much importance should not be attached to the "correct answer" scores; but when these scores show a class to be conspicuously below standard in calculation, the pupils should be given one of the series of tests described in Chapter IV. If these tests show the class to be below standard, the correctives prescribed in Chapter V should be used. Only one point needs comment here. If a class is found to be up to or above standard when tested on the operations separately, then the teacher has the problem of causing the pupils to use this ability in solving problems. Then the teacher should give less "isolated" drill — that is, drill upon examples — and more practice in the solving of problems.

A frequent source of error is the copying of figures. Some pupils copy the wrong figures, as 85 for 55. Others write all numbers as dollars pointing off two places. Still others, when they wish to subtract 240 from 60000, write

$$\begin{array}{l} 60000 \\ \underline{240} \end{array}$$

Type IV. Scores widely scattered. As in silent reading and the operations of arithmetic, frequently the scores of a

class will be found widely scattered or distributed. Some pupils will have relatively high scores, others will have very low scores. The remedy is to give individual or group instruction to those who have low scores. Those who have high scores also need special instruction. It may be that they should devote some of the time which they are now giving to the problems of arithmetic to some other subject. A few cases may be adjusted by a reclassification. The corrective instruction for those below standard can be best presented in connection with certain typical errors.

Neglect of certain technical words. An examination of ninety-five fourth-grade test papers revealed the following solutions of this problem: "How much more is earned per day by a man receiving \$30 per week than by a man receiving \$18 per week?"

Solution	Number
Solutions correct in principle	23 pupils
30 + 18 = 48	15 "
30 − 18 = 12	38 "
30 × 18 = 540	4 "
30 − 18 = 22	2 "
30 − 18 = 28	2 "
30 × 18 = 130	2 "
\$3.00 and \$5.00	3 "
30 − 18 = 12/30 more	2 "
3018 ÷ 7 = 4148	1 "
30 + 10 = 40	1 "
30 × 18 = 60.6	1 "

The solutions "30 − 18 = 12," "30 − 18 = 22," and "30 − 18 = 28" indicate that the pupils neglected the technical phrase "per day." If this phrase did not occur in the problem these solutions would be correct in principle. It might be that some of the pupils did not know the significance of this term. Solutions such as "30 + 18 = 48" and "30 × 18 = 540" indicate either a complete ignorance

of the technical term, "how much more," or failure to reason at all.

In the case of this problem, "A car contains 72,060 lbs. of wheat. How much is it worth at 87 cents a bushel?" many fifth-grade pupils gave no evidence that the number of pounds must be reduced to bushels. In the problem, "What are the average daily earnings of a boy who receives $0.88, $0.25, $1.15, $0.75, $0.50, and $0.60 in one week?" a very large per cent of the pupils failed to pay attention to the word "average." Its presence in the problem requires that the sum of the earnings be divided by 6.

The corrective for the neglect of technical terms is to teach the pupils their meanings. In this case the pupils who simply subtracted 18 from 30 need to be taught that "how much per day" when the amount is given for the week means division by the number of days in the week. When pupils do not know the meaning of "average" they must be taught.

Guessing instead of thinking. An excellent illustration of this type of procedure is given by Adams.[1] It occurred in an English school in what is the equivalent of our seventh grade. The problem, "If 7 and 2 make 10, what will 12 and 6 make?" is not the sort which we are accustomed to, but this fact does not destroy the value of the illustration:

> A look of dismay passed over the seventy-odd faces as this apparently meaningless question was read. Everybody knew that 7 and 2 did n't make 10, so that was nonsense. But even if it had been sense, what was the use of it? For everybody knew that 12 and 6 make 18 — nobody needed the help of 7 and 2 to find that out. Nobody knew exactly how to treat this strange problem.
>
> Fat John Thomson, from the foot of the class, raised his hand, and when asked what he wanted, said: —
>
> "Please, sir, what rule is it?"

[1] Adams, John, *Exposition and Illustration in Teaching*, pp. 176–78.

Mr. Leckie smiled as he answered: —

"You must find out for yourself, John; what rule do you think it is, now?"

But John had nothing to say to such foolishness. "What's the use of giving a fellow a count[1] and not telling him the rule?" — that's what John thought. But as it was a heinous sin in Standard VI [seventh grade] to have "nothing on your slate," John proceeded to put down various figures and dots, and then went on to divide and multiply them time about.

He first multiplied 7 by 2 and got 14. Then, dividing by 10, he got 1 2/5. But he did n't like the look of this. He hated fractions. Besides, he knew from bitter experience that whenever he had fractions in his answer he was wrong.

So he multiplied 14 by 10 this time, and got 140, which certainly looked much better, and caused less trouble.

He thought that 12 ought to come out of 140; they both looked nice, easy, good-natured numbers. But when he found that the answer was 11 and 8 over, he knew that he had not yet hit upon the right tack; for remainders are just as fatal in answers as fractions. At least, that was John's experience.

Accordingly, he rubbed out this false move into division, and fell back upon multiplication. When he had multiplied 140 by 12, he found the answer 1680, which seemed to him a fine, big, sensible sort of answer.

Then he began to wonder whether division was going to work this time. As he proceeded to divide by 6, his eyes gleamed with triumph.

"Six into 48, 8 an' nothin' over, — 2 — 8 — 0 an' no remainder. I've got it!"

Here poor John fell back in his seat, folded his arms, and waited patiently till his less fortunate fellows had finished.

James[2] knew from the "if" at the beginning of the question that it must be proportion; and since there were five terms, it must be compound proportion. That was all plain enough, so he started, following his rule:

"If 7 gives 10, what will 2 give? — less."

Then he put down

7 : 2 :: 10 :

[1] Scotch: any kind of arithmetical exercise in school work.

[2] The clever boy of the class.

"Then if 12 gives 10, what will 6 give? — again less." So he put down this time

12: 6

Then he went on loyally to follow his rule: multiplied all the second and third terms together, and duly divided by the product of the first two terms. This gave the very unpromising answer 1 3/7.

He did not at all see how 12 and 6 could make 1 3/7. But that was n't his lookout. Let the rule see to that.

After examining a large number of test papers, this account appears to the writer to describe the mental processes of a considerable number of pupils. They have not learned to think. The teacher insists that they "try" and they put down figures. They have been taught that it is worse to admit that they cannot solve a problem than to try it by unintelligent guessing. It seems that pupils should be taught to admit frankly that they do not know something when they don't know rather than to try to "bluff."

The corrective. Pupils are frequently taught to solve by rule rather than to reason. Rules are helpful when used properly, but teachers should train pupils to think, to associate definite meanings with technical terms, to combine these meanings and recalled rules into a plan of solution and to verify the proposed solution. To do this, the teacher should at first use simple problems, such as, "What is the area of a field 40 rods by 60 rods?" or, "What is the cost of 15 cows at $60 apiece?" and explain to the pupils that the words, "What is the area," "What is the cost," together with the form of the remainder of the statement of the problem, tell one what operation to perform. The words used in stating a problem when properly understood tell one what the plan of solution should be. Occasionally it is necessary to recall rules or principles, but these are suggested by the words of the problem. If this idea can be impressed upon a pupil, progress will have been made in teaching him to think.

Illustrations of failure to verify answer. Frequently pupils give answers which are absurd, thereby furnishing evidence of failing to apply even a common-sense check to their answers. The following are a few illustrations of this practice:

Problem: "A baker used 3/5 lb. of flour to a loaf of bread. How many loaves could he make from a barrel (196 lbs.) of flour?"

Solution: "3/5 of 196 lbs. = 117 3/5 loaves." This solution was given by a large number of sixth- and seventh-grade pupils. One sixth-grade pupil gave this: "3/5 × 39 = 39 1/3 loaves."

Problem: "At the rate of $4 for an 8-hour day, how much is due a man for 6 1/2 hours work?"

Solution (sixth grade): "13/2 × 4/1 = $26." This solution was given by a considerable number of pupils. Some sixth-grade pupils gave this: "8 − 6 1/2 = $2 1/2." One gave this, "6 × 4 = 24, 24 × 8 = $272 1/2."

The corrective. Some teachers recommend requiring pupils to estimate the answer before beginning the solution. For example, in the first problem above, the pupil could determine whether the number of loaves would be greater or less than the number of pounds of flour, 196. In the second problem, the pupil could determine whether a man would receive more or less for 6 1/2 hours than for 8 hours. This makes a common-sense verification a part of the solution of a problem.

Other reasoning tests. Several other tests have been devised to measure the abilities of pupils to solve problems involving reasoning, but none of them have been widely used. Some years ago Stone[1] worked out a reasoning test

[1] Stone, C. W., *Arithmetical Abilities and Some Factors Determining Them.* Teachers College Contributions to Education, no. 19. (1908.) See also Stone, C. W., *Standardized Reasoning Tests in Arithmetic and How to Utilize Them.* Teachers College Contributions to Education, no. 83. (1916.)

which has been used in several cities, and in a number of city school surveys, so that we have rather definite standards as to what may be expected from its use. Starch has devised a test which is called Arithmetical Scale A.[1] This scale included a number of the problems used by Stone, Courtis, and Thorndike. They have been evaluated upon the basis of difficulty and arranged in order of increasing difficulty. The pupils are allowed as much time as they need and a pupil's score is the value of the most difficult problem done correctly.

QUESTIONS AND TOPICS FOR STUDY

1. What are the steps in the solving of a problem in arithmetic?
2. To what extent and how is silent reading involved in solving problems?
3. Why must the problems which are used in a test be evaluated?
4. How would you go about teaching a pupil to reason in solving problems?
5. How could you find out whether your pupils are lacking in vocabulary or not?
6. On page 160 why is the form of solution on the second test better than the form on the first?
7. What reasons can you give for the absurd answers and forms of solution which many pupils give to problems? How could you correct these defects?

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[1] Starch, Daniel, "A Scale for Measuring Ability in Arithmetic"; in *Journal of Educational Psychology*, vol. 7, pp. 213–22.

CHAPTER VII

THE MEASUREMENT OF ABILITY IN SPELLING AND CORRECTIVE INSTRUCTION

Making a spelling test. In order that the method of measuring ability in spelling may be understood, certain things in connection with the making of a spelling test must be explained. The following questions are some which must be considered: (1) What words should be selected for a test? (2) How difficult should the words be? (3) How many words should be used? (4) How should they be given?

(1) Selection of words for a test on the basis of frequency of use. The English language contains many words. Some of these the average person never uses, others he uses only occasionally and a few he uses very frequently. For practical purposes there is no advantage in one being able to spell words which he never uses, and the makers of courses of study and textbooks in spelling are attempting to eliminate these words. Hence, it is obvious that such words should not be used to measure the ability of pupils to spell. Of the other two classes it is more important to be able to spell those words which are used most frequently, and for that reason they should be used in a spelling test if it is most helpful to the teacher. Hence, the first step in the selection of words for a test is to determine what words are used most frequently in written language.

Ayres's determination of the most commonly used words. In determining the most commonly used words, the method employed has been to examine written material of several types, such as letters, newspapers, and children's compositions, and to obtain a list of the words used and the number

of times each word occurs. Ayres [1] has combined the results of four such studies. Two of these studies were based on letters written by adults, the third upon newspapers, and the fourth upon selections of standard literature. The material examined in the four studies aggregated 368,000 words, written by 2500 different persons.

It was the original intention of Ayres to obtain a list of the two thousand most commonly used words, but this was impossible because the material examined was found to consist of a few words used many times, and of a larger number of words used only a very few times. It was found that fifty different words were used so frequently that they made up approximately half of the material examined. In order to secure a list of the thousand most frequently used words, it was necessary to include words which were found only forty-four times in the 368,000 words of material examined. Other studies have been made to determine the words which are used most frequently in written language, but the resulting lists have not been arranged in a form which is convenient to use for testing purposes. Hence, we shall limit this discussion of the measurement of spelling ability to the one thousand words of Ayres's list which is published with the title *A Measuring Scale for Ability in Spelling*.[2] However, one other study may be mentioned to illustrate further this method of determining the words which should receive attention in teaching spelling and in the measurement of spelling ability.

Jones's list of words used by school-children. Jones collected compositions from pupils in Grades two to eight inclusive. In order that a record of the complete writing

[1] Ayres, L. P., *Measurement of Ability in Spelling.* Bulletin of the Division of Education, Russell Sage Foundation. (New York City, 1915.)

[2] The reader should have a copy of this scale in order to properly understand this chapter. See Appendix for directions for ordering a sample package of tests.

vocabulary of each pupil might be obtained, a large number of compositions were written, the number per pupil ranging from 56 to 105. A total of 75,000 themes, consisting of a total of 15,000,000 words and written by 1050 pupils residing in four States, were examined. However, only 4532 different words were used by these pupils. Unfortunately, Jones does not tell us how many times each word was used so that we cannot obtain a list of the words which the children used most frequently.

(2) **Determination of the difficulty of words.** After we have a list of the most commonly used words, such as Ayres has given us, there remains the problem of determining the relative difficulty of the several words. It is a well-known fact that some words are more difficult to spell than others.[1] The words included in a test either must be equal in difficulty or their relative difficulties must be known. Otherwise we will be using a measuring instrument consisting of unequal units, but will be considering the units to be equal. Doing this makes our measurements inaccurate. The spelling difficulty of words for a given group of children may be determined by having the words spelled by them. From the per cent of correct spellings of each word the relative difficulty of the words may be calculated. Words which are misspelled an equal per cent of times by pupils of a given grade are equal in difficulty for that group. In the absence of this information it is practically impossible for a teacher to judge the difficulty of the words. Buckingham concluded that the judgment of a single teacher is almost of no value. "It may be good and it may be bad; and it is about as likely to be the one as the other."

[1] The spelling difficulty of a word has two interpretations. It may be taken to mean the difficulty which children have in learning to spell it. It may also refer to the frequency with which it is misspelled. The latter meaning will be used in this chapter.

How Ayres determined the difficulty of the words in his list. To determine the words of equal difficulty and the relative difficulty of the groups of words, Ayres divided the thousand words into fifty lists of twenty words each. Each list of words was spelled by the children of two consecutive grades in a number of cities. The thousand words were then divided into another fifty lists of twenty words each. Each of the new lists was spelled by the children in four consecutive grades. In all, 70,000 children spelled twenty words, making a total of 1,400,000 spellings, or an average of fourteen hundred spellings of each of the thousand words.

Upon the basis of this information Ayres classified the words into twenty-six groups, the words of each group being approximately equally difficult for school-children of a given grade.[1] This classified list, together with the per cent of pupils in each of the grades who spelled the words of each list correctly, has been printed with the title, *Measuring Scale for Ability in Spelling*. Strictly speaking, the Ayres *Measuring Scale for Ability in Spelling* is not a measuring instrument in itself, but rather a list of the foundation words of the English language, classified into twenty-six groups according to spelling difficulty. The teacher may use this list as a source of words for constructing spelling tests.

Pupils are not tested when words are too easy. When a pupil spells correctly all of the words of a given list, we do not have a measure of his spelling ability. We simply know that he can spell these words correctly; we do not have any information concerning how far beyond this list his spelling ability extends. In fact, the pupil has been given no opportunity to show how well he can spell. It is a well-known fact that the pupils of any grade or of any class are not equal in ability, but exhibit a wide range of ability.

[1] For the details of the method employed see Ayres, L. P., *Measurement of Spelling Ability*, pp. 22–35.

Thus, in testing a class it is necessary to use words for which the average per cent of correct spellings is less than one hundred. Ayres recommends that in making a test for the
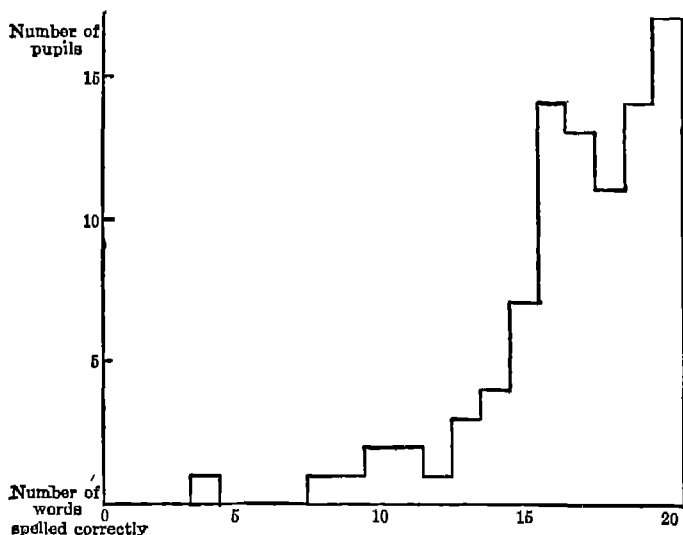
Fig. 28. Showing the Distribution of 91 Pupils according to the Number of Words spelled correctly.

Class average, 84 per cent.

pupils of a given grade, the words be taken from the column for which an average of eighty-four per cent of correct spellings may be expected.[1]

Fig. 28 represents a typical result of using the words chosen as Ayres recommends. Compare the shape of this distribution with the shape of Figs. 1 and 2. These fig-

[1] The reader should not confuse scores or measures of ability with school marks. The per cent of correct spellings is a measure. The school mark is the meaning which the school attaches to that measure. The fact that both the measure and the school mark may be expressed in per cents does not make them the same.

ures were presented as evidence that teachers' marks were inaccurate. The class average is eighty-four per cent, but those pupils who spelled all of the words correctly have not been tested. Those who misspelled only one or two words probably have not been tested satisfactorily.

Otis[1] presents facts from which he concludes that the most reliable measures of spelling ability are obtained by using words for which there is an average of fifty per cent of correct spellings. In support of this conclusion he points out that a list of words for which the average per cent of correct spellings was either zero per cent or one hundred per cent, would yield a measure of zero reliability. Likewise a list of words for which the average per cent of correct spellings was ten per cent or ninety per cent, would yield measures only slightly more reliable. Hence, it seems natural that the most reliable measures would be obtained by using a list for which the average per cent of correct spellings was fifty. On the other hand, some writers claim that it is not wise to have pupils spell words incorrectly. They point out that every repetition tends to fix a habit.

Ayres gives no satisfactory justification for recommending the choice of words for which an average of eighty-four per cent of correct spellings may be expected. When measuring the spelling ability of children in Springfield, Illinois, Ayres used words for which seventy per cent of correct spellings had been obtained. For the Survey of Cleveland, Ohio, the words were chosen from columns for which the average per cent of correct spellings was seventy-three. Thorndike has used words for which the per cent of correct spelling is fifty.[2] For these reasons it is probably best

[1] Otis, A. S., "The Reliability of Spelling Scales"; in *School and Society*, vol 4, p. 753.

[2] Thorndike, E. L., "Means of Measuring School Achievement in Spelling"; in *Educational Administration and Supervision*, vol. 1, p. 306.

to choose words from columns for which the average per cent of correct spellings is approximately seventy.

(3) **How many words to use.** Another question which must be considered in making a spelling test is the number of words it is necessary to use. In general the ability to spell one word is separate and distinct from the ability to spell any other word. Ability to spell, therefore, consists of a large number of abilities to spell specific words. This being the case it would be necessary to use all of the thousand words of Ayres's list in order to obtain a complete and accurate measure of a pupil's ability to spell the most commonly used words. However, it is possible to secure a measure which is representative of the pupil's ability to spell these words by using a smaller number of words. This is possible in just the same way that it is possible to determine the quality of a load of wheat or a vat of cream by the examination of a sample.

How many words are necessary in making a spelling test depends upon what is desired. Relying upon the theory of random sampling, Thorndike believes a small number of words is sufficient to measure the spelling achievement of a large school system. A test consisting of only ten words has been used in a number of school surveys. This number is probably sufficient for the measure of a large school system, but if it is desired to obtain a measure of the spelling ability of individual pupils, a larger number must be used. Otis[1] says that a twenty-five-word test gives a very poor measure of individual ability, and that at least one hundred words should be used, better four hundred or five hundred words. Starch recommends the use of two hundred words. Therefore, it is probably best to use as large a list of words as the time which the teacher can use for measuring spelling will permit. At least fifty words should be used if possible.

[1] *Loc. cit.*, pp. 679, 682.

(4) **How should the words be given.** The complaint is frequently made that pupils spell words correctly in the spelling class, but misspell the same words when writing compositions and other school exercises. One reason why this occurs is that in the spelling class the pupil has his attention fixed upon the spelling of the word and takes time to do his best. In writing a composition, his attention must be centered upon what he is writing, and thus he is able to give only partial attention to the spelling. Also he probably writes more rapidly. Hence, we may recognize two types of spelling ability: (1) the ability to spell words when one's attention is focused upon the spelling; (2) the ability to spell words when one's attention is focused upon other things and the spelling is carried on in the margin of consciousness.

The words which make up a test may be dictated to the pupils as separate words, or they may be embedded in sentences which are dictated. Furthermore, the dictation of the sentences may be timed so that the pupils are forced to write at their normal rate. In this way we are able to secure approximately the second type of spelling. Investigation has shown that the per cent of correct spellings is higher when the words are dictated separately than when they are dictated in timed sentences and the pupils are forced to write at their normal rate. According to Courtis the per cent of correct spellings is about five greater when the words are dictated in lists. Fordyce has found this difference to be between ten and fifteen per cent. The writer has found a difference of more than six per cent.

In writing letters, compositions, and the like, the spelling must be carried on in the margin of the attention because the ideas which are being expressed must occupy the focus of the attention. This is particularly true of the foundation words of the language such as we have in the Ayres list. The words of this list constitute over ninety per cent of the

words we use. Hence, by using the words embedded in sentences and dictated rapidly enough to force the child to write at his normal rate, we measure the spelling ability which functions in one's every-day writing.

The rate of dictation. Pupils may be caused to write at approximately their normal rate by dictating the sentences at that rate. The Freeman's standards for rate of handwriting are as follows in terms of letters per minute: second grade, 36 letters; third grade, 48 letters; fourth grade, 56 letters; fifth grade, 65 letters; sixth grade, 72 letters; seventh grade, 80 letters; eighth grade, 90 letters. The dictation of a sentence requires some additional time, probably ten per cent. For example, in the case of the sixth grade, instead of dictating at the rate of 72 letters in one minute, 66 seconds should be allowed for words totaling 72 letters. On this basis the number of seconds to be allowed per letter for the several grades are as follows: —

Grade	*Seconds per letter*
II	1.83
III	1.38
IV	1.18
V	1.01
VI	.92
VII	.83
VIII	.73

If the sentences contain more than thirty to forty letters, they should be dictated in sections, so that the pupil's writing will not be slowed up by trying to recall what has been dictated. Furthermore, tests of rate in handwriting have shown that all pupils do not normally write at the same rate. For this reason provision must be made for those pupils who are accustomed to write more slowly than the standard rate. This can be done by having none of the test words come at the end of the sentences, and requiring all pupils to

begin upon the next sentence as soon as it is dictated, even if they have not finished writing the preceding.

Summary: The discussion of the making of a spelling test may be summarized as follows:

1. The Ayres Measuring Scale for Ability in Spelling is a list of the one thousand most commonly used words of the English language. These words have been classified according to difficulty and words chosen from one column may be considered as being equally difficult. When words are taken from more than one column the inequality of difficulty must be recognized, if an accurate measure is to be secured.

2. Twenty words are probably sufficient to secure a reliable measure of the spelling ability of a class. At least fifty words should be used to secure a reliable measure of the spelling ability of individual pupils. More accurate measures will be obtained by using one hundred words. In the case of the upper grades it will be necessary to use words from more than one column. When this is done the relative difficulty of the words must be recognized to secure an accurate measure.

3. In order that the words may be difficult enough to really measure the spelling ability of all pupils, the words should be chosen from columns for which the standard per cent of correct spellings is approximately seventy. For the lower grades it is probably best to use words for which the standard per cent of correct spellings is from fifty to sixty-six. If the words are to be used in timed sentences it will probably be satisfactory to use easier words.

4. In order to secure the best measurement of spelling ability, the words should be embedded in sentences, and the sentences dictated at approximately the standard rate of handwriting for the grade. Test words should not occur at the end of the sentences.

A timed sentence spelling test. In order to illustrate the

type of test described above, we reproduce the directions and a test arranged for the fourth grade. The rate of dictation of this test was determined upon the basis of measurements of the handwriting rate of six thousand Kansas school-children.

Directions for Giving a Timed-Sentence Test

1. See that the pupils are provided with two or three sheets of paper and with either pencil or pen and ink. If pencils are to be used they should be well sharpened. If pen and ink are used, good pens should be provided.

2. Make certain that all pupils understand what they are to do. It is well to give a short preliminary practice in writing from dictation if the pupils are not accustomed to it. For this purpose use some simple selection.

3. It is well not to tell the pupils that they are being tested in spelling. Under no circumstances indicate the test words by emphasis in dictating.

4. When everything is ready, say to the pupils: "I have some sentences which I want you to write as I dictate them. I am going to dictate them rather rapidly, possibly more rapidly than some of you can write. If you have not finished writing one sentence when I begin to dictate another, I want you to leave it and begin on the new sentence. If there are any words you cannot spell, you may omit them. Take time to dot your i's and cross your t's. If you have any question about what you are to do, ask it now, because you cannot ask questions after I begin to dictate."

5. Use the arrangement of the sentences which has been prepared for the grade you are testing. If a teacher has two divisions of different grades, as 5B and 6A, she must test the two divisions separately, using the test which is arranged for each grade. When the second hand of your watch is at 60 read the first sentence. When the second hand reaches the next number printed in the margin, read the second sentence. Dictate the other sentences at the time indicated. Dictate the sentences distinctly, but *do not repeat.* Be careful not to suggest the spelling of the words by unduly emphasizing certain syllables. It is advisable for the teacher to practice dictating the sentences according to the directions before attempting it with a class.

6. Stop the pupils promptly at the time indicated. *Allow no corrections or additions to be made.* Ask the pupils to turn their papers over and write their name and grade. Appoint two or three pupils to collect the papers.

A TIMED-SENTENCE TEST ARRANGED FOR THE FOURTH GRADE

Test words taken from column M of the Ayres Scale

Seconds

60 He *bought* a *railroad ticket* to the city.
41 *Collect* the *account* before Sunday.
18 *Those children* will *return* soon.
53 *Anyway* she is *ready* to go.
19 *Please omit both* names.
44 *Few change* trains here.
9 He *says* the *great office* is full.
43 *Who died* this morning?
6 The *money* for the *picture* was *paid* to us.
47 The *members* did not *understand* him.
24 *Again* he *took* the car.
46 It will *provide* an *income* in his old age.
27 The *army* had *begun* to *drill* in the park.
7 He *might begin* the *contract* next week.
47 I was *unable* to *recover* the bill.
21 I have an *extra dress* with me.
51 The *deal* was *almost* closed.
19 Did you *inform* him to *follow* the car?
56 The *past month* I was in the south.
30 *While* he *goes* home, you stay.
58 The car was *driven beside* the train.
35 I saw him *enter* the place.

When the second hand reaches 1, stop the writing.
Allow no corrections or additions to be made. Ask the pupils to turn their papers over and write their name and grade. Appoint two or three pupils to collect the papers.

Marking the test papers. The most accurate results will be obtained when the teacher marks the test papers for incorrect spellings and omissions of test words, but unless

the teacher has sufficient time for this work the papers may be marked by the pupils. When this plan is followed the teacher should spell out the test words and have the pupils mark with a cross words misspelled and words omitted. (When a timed-sentence test is used no attention is given to words which are not test words.) The number of test words correctly spelled should be written at the top of each pupil's paper. This is the pupil's score. By dividing the number of words spelled correctly by the number in the test, the per cent correct is obtained.

Recording the scores. For recording the scores of a class a record sheet such as shown in Fig. 29 should be used. (This record sheet is used for a fifty-word test.) In this way the teacher obtains a statement of the number of pupils who spelled forty words correctly, the number who spelled forty-one words correctly, etc. The class score may be found by adding the scores of all of the pupils together and dividing this sum by the number of pupils. This quotient is the average. For practical purposes it is just as satisfactory and more convenient to find the median. This may be done by arranging the test papers in the order of the number of words spelled correctly, the lowest score on the bottom. The score on the middle paper is the median score.

Standards: *(1) The Ayres Scale.* In classifying the words of his list according to difficulty, Ayres determined the average per cent of the pupils of each grade who spelled the words correctly. Thus the words of column O were spelled correctly by 50 per cent of the third-grade pupils, 73 per cent of the fourth-grade pupils, 84 per cent of the fifth-grade pupils, 92 per cent of the sixth-grade pupils, 96 per cent of the seventh-grade pupils, and 99 per cent of the eighth-grade pupils. These per cents, which are printed at the head of each column, represent the average spelling ability of pupils in the several grades when the words are dictated in

Distribution of Pupils' Scores

Number of words spelled correctly	Number of pupils	Number of words spelled correctly	Number of pupils
50		Sub. Total	
49		24	
48		23	
47		22	
46		21	
45		20	
44		19	
43		18	
42		17	
41		16	
40		15	
39		14	
38		13	
37		12	
36		11	
35		10	
34		9	
33		8	
32		7	
31		6	
30		5	
29		4	
28		3	
27		2	
26		1	
25		0	
Sub. Total		Total	
		Median Score	

FIG. 29. SHOWING THE RECORD SHEET FOR RECORDING PUPILS' SCORES ON A SPELLING TEST OF FIFTY WORDS

lists. When the words are used in timed sentences the averages have been 5 to 15 per cent lower.

It may be seriously questioned whether the averages which Ayres gives are satisfactory standards of spelling ability for the foundation words of the language. Ayres says: "Probably the scale will have served its greatest usefulness in any locality when the school-children have mastered these one thousand words so thoroughly that the scale has become quite useless as a measuring instrument." In the past we have not had the advantage of such a list and have distributed our efforts in teaching spelling over a very much larger list of words. If we accept these one thousand words as the foundation words of our language, we should place prime emphasis upon teaching them. This being the case a satisfactory eighth-grade standard would approximate one hundred per cent for all of the words. For the preceding grades the standard would be one hundred per cent for the words of the list which the pupils had been taught. For example, the easiest nine hundred words might be used for the seventh grade, the easiest seven hundred and fifty for the sixth grade, and so forth. The use of the scale in the way Ayres suggests would seem to lead to standards of this type. The distribution of the words among the several grades and the optimum standards must be determined by experimentation.

(2) *Timed-sentence spelling tests.* A series of timed-sentence spelling tests similar to the one reproduced on page 186 was given to several thousand children in Kansas about the seventh month of the school year. The median scores are given in Table XX, and they may be used as tentative standards for timed-sentence spelling tests of the type reproduced on page 186, but it must be remembered that as we improve our teaching of spelling our standards should be raised.

TABLE XX. SHOWING MEDIAN SCORES FOR A TIMED-SENTENCE SPELLING TEST OF FIFTY WORDS

Grade	*Number of pupils tested*	*Median scores. Number of words spelled correctly*	*Per cent of words spelled correctly*	*Ayres's standards*
III..........	997	28	56	66
IV..........	1060	39	78	84
V..........	1009	33	66	73
VI..........	870	40	80	84
VII..........	826	35	70	79*
VIII..........	608	42	84	88*

* The test for the seventh and eighth grades consisted of words taken from three columns. Hence these standards are only approximate.

Causes of low class scores. As in the case of other subjects the teacher should use the results of spelling tests as a basis for planning instruction which will correct the defects that the tests reveal. A class score below standard indicates an unsatisfactory condition which may be due to one or more of the following conditions:

1. The class as a whole may be unable to spell certain words.
2. Certain pupils may be unable to spell a large number of the words of the test.
3. The errors may be rather uniformly distributed as to both words and pupils.

To determine the extent to which each condition causes the low class average, the teacher should make the following type of tabulation from the test papers. This will give a record of each pupil for each word of the test. Instead of designating the pupil by number as in this illustration their names or initials can be used at the head of the columns.

Words of the test	*Pupils*											
	1	2	3	4	5	6	7	8	9	10	11	12
catch	c	–	–	–	c	–	–	–	–	c	–	c
black	c	c	c	c	–	c	c	c	c	c	–	c
warm	c	c	c	c	c	c	c	c	c	c	c	c
unless	c	c	c	c	c	c	c	c	c	c	–	c
clothing	c	–	c	–	–	c	–	–	c	c	–	–
began	c	c	c	c	c	c	c	c	c	c	–	c

c indicates the word was correctly spelled.

Although these words are listed by Ayres in his Spelling Scale as being equally difficult for pupils in general, they are not necessarily so for particular pupils. Obviously in the class here represented "catch" and "clothing" need general emphasis, while only certain pupils need to give attention to "black," "began," and "unless." Pupil 11 has misspelled five out of six words, and hence probably is a "poor speller."

What a spelling test reveals. Such a tabulation of the results of a test is valuable because it reveals the character of the spelling ability of the class. It points out the "poor spellers." It indicates whether the class as a whole find some words difficult to spell or the misspellings are uniformly distributed. However, it must be remembered that the test contains only a limited number of words, and although the results may be accepted as indicating the nature of the conditions which exist, it cannot tell the teacher all the words for which corrective instruction must be planned. Simply to know that a pupil is below standard in ability is of little value to the teacher, because in general the ability to spell one word does not imply ability to spell another word, nor does the lack of ability to spell a given word indicate that a

pupil cannot spell another word. But the fact in the above illustration that most of the class could not spell correctly "catch" and "clothing" indicates that there are several words which the class as a whole do not know how to spell. On these words class instruction is needed. When the teacher knows the type of situation with which he has to deal he should then proceed to determine the particular words which all or certain pupils need to learn to spell. At least the teacher should make a very careful diagnosis of the spelling ability of each pupil whose test score is below standard, to ascertain just what words he cannot spell of those he is expected to spell.

This is accomplished by giving the pupils below standard a test including all of the words which they are expected to be able to spell. Such a test is not for the purpose of measurement, but should be thought of as the first step in the teaching of spelling. Each pupil should be required to make from this test a list of all the words which he has spelled incorrectly. The words of this list are the ones he needs to study. It is obvious that to ask a pupil to study words which he can already spell correctly is to ask him to use his time without profit.

Class correctives. "Spelling Demons." Certain frequently used words are very frequently misspelled. Jones[1] has given us a list of one hundred words which he found misspelled most frequently in children's compositions. He calls them the "One hundred spelling demons of the English language." Nine tenths of these words are found in Jones's list for the second and third grades. Four fifths of these words are found in Ayres's list. Because these words are frequently misspelled and are among the commonly used words of the language a teacher will make no mistake in emphasizing these words in the teaching of spelling until the pupils can spell them correctly.

[1] See pages 176–77 for a description of Jones's study.

THE ONE HUNDRED SPELLING DEMONS OF THE ENGLISH LANGUAGE

which	can't	guess	they
their	sure	says	half
there	loose	having	break
separate	lose	just	buy
don't	Wednesday	doctor	again
meant	country	whether	very
business	February	believe	none
many	know	knew	week
friend	could	laid	often
some	seems	tear	whole
been	Tuesday	choose	won't
since	wear	tired	cough
used	answer	grammar	piece
always	two	minute	raise
where	too	any	ache
women	ready	much	read
done	forty	beginning	said
hear	hour	blue	hoarse
here	trouble	though	shoes
write	among	coming	to-night
writing	busy	early	wrote
heard	built	instead	enough
does	color	easy	truly
once	making	through	sugar
would	dear	every	straight

Class drill. Courtis[1] recommends a form of class drill which may be used when the class as a whole are learning to spell a word:

> The word to be learned is pronounced by the teacher and class together and then written letter by letter as it is spelled aloud. This is repeated five or six times in rapid succession. The rate of writing should be slow at first, then faster and faster (like a college yell), until at the sixth repetition only the most rapid writers are able to keep up with the class.

Spelling games. In the manual referred to above, Courtis describes the following games which may be used for pro-

[1] Courtis, S. A., *Teaching Spelling by Plays and Games* (82 Eliot Street, Detroit, Michigan), p. 8. This is an excellent manual for teachers. It contains explicit directions for a number of spelling games.

viding drill upon spelling. They are particularly helpful when a stronger motive is needed. Each of these games provides for dividing the pupils in a room into two teams or groups and for keeping scores for a week or a month:

1. Syllable game.
2. Jumbled-letter game.
3. Initial game.
4. Rhyming game.
5. Derivative game.
6. Definition game.
7. Linked-word game.
8. Missing-word game.
9. Composition game.

Individual correctives. Types of misspellings. A pupil's spelling difficulty is not completely diagnosed when the words he does not spell correctly are located. Errors in spelling are seldom if ever distributed uniformly among the several letters composing the word. Neither does it appear that there is much uniformity in the location of errors in different words. Certain words are misspelled in only a few ways, while other words are misspelled in many ways. Certain misspellings occur frequently, while others seldom occur. In Table XXI the misspellings of certain words found in the papers of eighty seventh-grade pupils are given, together with the frequency of each. The words were taken from column S of the Ayres Scale. Where no number follows the word that type of misspelling of the word occurred but once.[1]

Causes of some misspellings. A study of Table XXI shows that certain forms of misspelling occur more frequently than others, and that most of the misspellings may be attributed to certain specific causes. Forms of misspell-

[1] See also Sears, J. B., *Spelling Efficiency in the Oakland Schools.* Board of Education Bulletin, Oakland, California, p. 51.

TABLE XXI. THE MISSPELLING OF EIGHTY SEVENTH-GRADE PUPILS ON A COLUMN SPELLING TEST

I. affair
- affere
- affire
- afair (2)
- affaired
- affer

II. assist
- assit (3)
- aisst (2)
- ascist
- assest
- assaist
- asscest
- assiast
- acsist
- acist (2)
- accisted
- assantant
- assised
- accessese
- accest
- astist
- assis
- assite

III. certain
- certian (7)
- serten
- sertain
- certin
- secrtain

IV. difference
- differance (10)
- diffierence

V. examination
- examation (10)
- examition
- examnition
- excamation
- excanitions
- examanation (3)

VI. government
- goverment (9)
- govament
- govercnement
- gorvement

VII. improvement
- improvment (7)
- impovement

VIII. investigate
- investagate (3)
- envesigatige
- investiage

IX. marriage
- marrage (5)
- marage
- merriage

X. mention
- mension (8)
- mensioned
- meantion (2)
- menchion

XI. motion
- moshen
- moticem
- motation
- montion

XII. neither
- neather (6)
- nether
- niether (2)
- nieghter

XIII. opinion
- oppinion (5)
- opinon (2)
- opinton
- oppoinen
- oppinum
- oppenion (2)
- opion (3)
- oponion (2)
- oppion (2)
- opinnion
- opoin (2)
- opionion

XIV. particular
- particuliar
- particuler
- partictuler,
- perticular (8)
- particlar
- pertucular
- partcular
- partiular
- partular
- paticular
- perciluar
- pectuliar
- pecticular
- pertictural
- patuclure
- peculiar
- pectulair

XV. possible
- possable (4)
- posible
- posable
- posiable (2)
- possiable (5)
- posobile
- possibbe
- posiple

XVI. serious
- cyreaus
- cerrious
- scerious
- serrious (2)
- cerious
- sereaus

XVII. stopped
- stoped (13)
- stopts
- stocted
- stop

ing such as "partiular," "partuler," "opinon," "impovement," "possibbe," are probably due to carelessness or accident, "a slip of the pen." Relatively few of the misspellings in this table may be assigned to this cause. Errors of this type probably cannot be entirely eliminated from un-

corrected manuscript. However, drill will reduce the number of such errors to a satisfactory minimum.[1]

An important source of error is mispronunciation of the word by the pupil. He may have acquired this from the teacher, but more likely from those with whom he associates outside of school. Or it may have been acquired from lack of attention to the form of the word. Such misspellings as the following are probably caused by mispronunciation: "perticular," "particlar," "investagate," "goverment," "examation."

A very striking instance of this type of spelling error and its cause came to the attention of the writer a few years ago. A man who had taught geometry for a number of years used the word "frustum" in a manuscript, spelling it "frustrum" which agreed with his pronunciation of the word. This manuscript was read by a number of well-known mathematicians who read it critically. Only two noted the misspelling of the word, and one mathematician, who took much pride in his ability to spell correctly and who was the author of several textbooks, admitted that he had always pronounced and spelled the word "frustrum."

Other errors listed in Table XXI are due to certain phonic irregularities of the English language, for example, certain misspellings of "assist," "certain," "affair," "marriage," "motion," "neither," and "serious." Such errors occur more frequently in connection with vowels than with consonants. Still other errors, such as "stoped," and "improvement," are due to certain doubled or silent letters.

The length of words and the position of the letters are responsible for some errors. In general there is a close agreement between the number of letters in a word and its rela-

[1] Errors of this type have been called "lapses" See Hollingworth, Leta S., *The Psychology of Special Disability in Spelling*, Teachers College, Columbia University, Contributions to Education, no. 88, p. 38, for a complete statement of types.

tive difficulty. The longer the word, the more difficult it is to spell. In Table XXI it is obvious that the errors are not uniformly distributed among the several letters of a word. For example, consider "examination," the fifth word in the table. The letters *e-x* and *t-i-o-n* were given correctly in every case. The first *a* also occurs. In every case except one, the letter *m* is given. Fifteen out of the seventeen errors occur in connection with three letters, *i-n-a*. The explanation of this condition, which is typical, is that correct spelling "depends mainly upon a correct visual or audile image coördinated with the correct motor control." [1] Some letters are more conspicuous than others in the form of the printed, or written, word and also in the sound of the spoken word. In general, the letters occupying the initial positions are remembered best for this reason.

Some words are spelled incorrectly because the pupil has not learned any spelling, correct or incorrect, for the word. In such cases if the pupil is asked to spell the same word several times, different spellings will be given. Hollingworth gives an illustration of this type. One pupil misspelled "saucer" in seven different ways in nine successive writings of the word: "s-a-u-e-c," "s-u-s-s-e," "s-u-c-c-e-r," "s-u-c-c-e-r-e," "s-u-r-r-e-s," "s-u-s-s-e-r," "s-u-c-e," "s-u-s-s-e-r," "s-u-c-c-e-r." Other words are misspelled because the pupil has learned an incorrect spelling. This was the case in the misspelling of "frustum" described above.

Still another cause of misspelling is a lack of the knowledge of the meaning of the word. Hollingworth states: [2]

On the basis of these data we conclude that *knowledge of meaning is probably in and of itself an important determinant of error in*

[1] Kallom, Arthur W., "Some Causes of Misspellings"; in *Journal of Educational Psychology*, vol. 8, p. 395.

[2] *Psychology of Special Disability in Spelling*, p. 57.

spelling; that children will produce about sixty-six and two-thirds per cent more of misspellings in writing words of the meanings of which they are ignorant or uncertain, than they will produce in writing words the meaning of which they know.

Teaching the pupil to correct his errors in spelling. Spelling consists in forming correct and fixed associations "between the successive letters of a word and between the word thus spelled and the meaning."[1] The laws governing the formation of fixed associations are those of habit formation. The first step in habit formation is to get the attention of the child focused upon the associations to be formed. The second step is to secure sufficient repetition. Repetition of the associations is secured both through drill and through using the word in written expression. The pupil must give attention to the repetitions of the associations in order to insure that wrong associations will not be made.

The causes of misspelling given above suggest certain correctives. If the error is due to an incorrect pronunciation of the word, the pupil should be taught the correct pronunciation. The phonic irregularities of words should be emphasized. In the case of long words the pupil's attention should be directed to the letters in the middle of the word. The meaning of the word should be connected with the pupil's experience. This does not mean merely requiring him to use it in a sentence.

As in the case of other school subjects motive is an important factor in learning to spell. A strong motive can be secured by the use of standardized spelling tests. Definite standards should be set and at intervals careful tests should be made. Charts showing the scores of the individual pupils as well as the class score in comparison with the standard will be helpful.

[1] Freeman, F. N., *Psychology of the Common Branches*, p. 115.

Numerous experiments have shown that pupils can spell correctly a large per cent of the words in the lists in spellers before they have studied them. Because of this fact the assignment of the spelling lesson should include the dictation of the words to the pupils so that each might know what words he needed to study. The teacher would also learn what words he should emphasize in his instruction.

Some writers state that a pupil should not be permitted to spell a word incorrectly when it can be avoided, and for this reason pupils should learn to spell words correctly before they are required to write them. Just how important it is to do this we do not know. In certain cases it appears that a child or an adult learns to spell certain words correctly by having his attention directed to his errors. The fact of his error serves to direct his attention to learning to spell the word correctly. Those who believe that evil effects will come from having pupils write words which they cannot spell correctly, may direct them to omit those words which they think they cannot spell correctly.

The dictation of the words in assigning the spelling lesson, together with the detailed testing of the pupils as suggested on page 191, reveals to the teacher the words upon which he must exercise his ability as a teacher of spelling. It also reveals to him the pupils to whom instruction should be directed in the case of each word. Particular methods and devices by means of which the laws of habit formation may be fulfilled are described in books which deal with the teaching of spelling.[1]

A device for focusing attention upon the difficult portion of a word. In teaching the spelling of a word the child's attention should be directed to the crucial associations. If the word is one like "government," his attention should

[1] A very good chapter (VI) will be found in Freeman's *Psychology of the Common Branches.* See also Cook and O'Shea, *The Child and his Spelling.*

be called to the correct pronunciation. If it is such a word as "their," his attention should be called to the use of the word. To eliminate spelling errors a pupil's attention should be called to his particular error and he should be helped to remove the cause. If the cause is mispronunciation, see that he learns to pronounce the word correctly. If the error is due to a confusion of letters, the pupil should be given some device to prevent this confusion. The following is a device which may be used for especially difficult words:

Par-tic-u-lar

I frequently misspell .... in writing compositions but now I am going to learn to spell it correctly. My teacher tells me that I do not look at the .... syllables and letters closely enough. I am going to do it now with .... care. I see that the word has .... syllables. The first syllable is .... The vowel of this syllable is ...., the first letter of the alphabet. The last syllable is .... and the vowel is also .... The word contains .... letters, the other vowels are .... and .... Now that I have looked at the word carefully I am going to be very .... in spelling it. I am also going to be .... in pronouncing it. I am going to remember that the vowel in the first syllable and in the last syllable is an .... I am not going to pronounce those syllables as if the vowel were *e* instead of .... I am going to be very .... about both spelling and pronouncing this word. I want it to be correct in every..........

This device is used by providing the pupil who needs instruction with a printed or typewritten copy. The pupil is required to fill in the blank spaces correctly. This is repeated until the correct associations are fixed.

Drill for making associations automatic. Getting the pupil to spell a word correctly is only the first step. There must be attentive repetitions of the correct associations until they have become automatic. In this respect spelling is similar to arithmetic. In the teaching of the operations

of arithmetic, drill occupies a prominent place, but in the case of spelling our teaching has been confined primarily to testing pupils. Requiring pupils to write each misspelled word ten or twenty times is an effort to provide practice. Such practice is unsatisfactory. After the first writing of the word the pupil probably copies. Hence the repetitions are not attentive.

Practice upon words which are misspelled by a majority of the pupils can be secured by having them recur in the spelling lesson from day to day. This plan provides the same drill for all pupils regardless of whether they misspell the word or not. In this respect it is unsatisfactory. The pupils may be required to write material which the teacher dictates. When carrying on this kind of practice, the teacher dictates as rapidly as the pupils can write, or better, calculates the number of seconds required to write each sentence, or part of sentence, as was done for the timed-sentence spelling test. (See page 186.) This can easily be done by using the rates given on page 183.

"Developing a spelling consciousness." The following device serves to direct the pupil to see his errors in a wholesome way. It has yielded very gratifying results in the Training School of the Kansas State Normal: [1]

When the spelling sentences or lists have been written, each pupil is required (1) to mark each word, the spelling of which he doubts; (2) as far as possible he is encouraged to test the validity of his doubts by known means outside of the dictionary, finally checking up all doubted words by using the dictionary; and (3) he then writes all of the misspelled words, which he has thus detected, correctly spelled in separate lists; (4) at this point the pupils' papers are exchanged, the teacher spelling all words and the pupils

[1] Lull, Herbert G., "A Plan for Developing a Spelling Consciousness"; in *Elementary School Journal*, vol. 17, p. 355.

marking those found to be misspelled on the papers; and finally (5), when the papers are returned to their owners the additional misspelled words discovered should be added to their individual lists.

The pupil's spelling is scored by the teacher on the basis of the correctness of his doubts as well as upon the number of words spelled correctly. In the absence of a scientific determination of the relative significance of *spelling of words correctly* and *doubting correctly*, the same value is assigned to each. The pupils are scored both for doubting words spelled correctly, and for not doubting words spelled incorrectly.

QUESTIONS AND TOPICS FOR STUDY

1. Measure the spelling ability of the pupils of your class by means of a timed-sentence test and then dictate the test words as separate words. Compare the two sets of scores.
2. Teachers frequently tell with pride that all but two or three of their pupils make a "grade of 100" on a certain test. Should the fact be a cause for a feeling of satisfaction? Were the pupils really tested?
3. Dictate the words for the next spelling lesson before the pupils have studied them. Have each pupil make a list of the words which he misspells and also of the particular misspellings which he has used. Direct the pupils to base their study upon these lists.
4. Construct a series of "timed-sentence spelling tests" for the elementary school, using suitable words from the Ayres Scale.
5. Why does a test of easy words fail to give a measure of spelling ability?
6. Why must the relative difficulty of the words of a test be known if accurate measures are desired?
7. Make a study of the ways in which your pupils misspell words. Also ascertain the causes for these misspellings.
8. How can you use this information in making your teaching of spelling more effective?

CHAPTER VIII

THE MEASUREMENT OF ABILITY IN HANDWRITING

The measurement of ability in handwriting involves (1) the measurement of the rate of writing and (2) the quality. The rate is measured by having the pupil write under specified conditions for a convenient number of minutes and counting the number of letters written per minute. The measurement of quality is accomplished by securing a sample of the pupil's handwriting and determining the specimen on a handwriting scale which is equivalent to it in quality. The quality may also be measured by means of a score card.

The measurement of the rate of handwriting. In measuring the rate of handwriting certain points must be kept in mind.

(1) The teacher should see that all pupils are provided with good pen-points, ink, and paper unless they use pencils, in which case there should be a sufficient supply of well-sharpened pencils. All pupils should be supplied with two or three sheets of suitable writing-paper.

(2) The pupils should be asked to write a sentence or a paragraph which they have memorized. To guard against lapses of memory, the pupils should be asked to repeat in concert the selection to be used. If convenient it is well to provide each pupil with a printed or typewritten copy of the selection. When this cannot be done, the selection may be written on the blackboard where all can see it. The selection should contain no words which the pupils cannot spell readily. It is well to have them practice writing the more difficult words before the test is begun. Do not use material which the pupils must compose as they write, for

this would be worthless in testing. The rate of writing unfamiliar material from a printed copy will vary with the pupil's rate of reading and so will not give a true measure of his rate. Dictated material should be used only when the teacher wishes to control the rate, not when the rate is to be measured.

(3) The teacher must be provided with a watch which has a second-hand or with a stop-watch. A two- or three-minute period should be allowed and the teacher should exercise care to make this period exact.

(4) Pupils probably have two or more rates of writing, one for the penmanship class when they are doing their best and another for writing exercises in history, language, or other school subjects. The way in which the teacher gives the directions to the class will influence their rate. If he tells the pupils or even suggests that they are expected to show how well they can write, the rate will probably be low. On the other hand, if the pupils are given the idea that the rate is most important, they will write more rapidly than they are accustomed to do. It is, therefore, important that a teacher follow directions which have been prepared for securing samples of pupils' handwriting. We give below a set of directions which have been widely used.

Directions for Obtaining Samples

When children have paper and pencil proceed thus: Read aloud a stanza — four lines of the poem, "Mary had a little lamb," etc., which is printed below. If you are using these directions for the first time use the first stanza; if the second time, use the second stanza; if the third time, use the third stanza. Have the children recite this stanza aloud in unison until you are sure they all know it. Then ask them to write it once. Collect these copies and destroy them. *Do not tell the children they are to be tested in any way.* Next instruct the children as follows:

"Write the stanza of the poem which you have learned. Write it just as you would in a composition or in an ordinary school

exercise. If you finish the stanza, write it over again, and keep on writing until I tell you to stop. Write on only one side of the paper. When you fill one page use another. We must start together and stop together. Lay your papers on your desk in position. Have pen and ink ready. When I say 'Get ready,' ink your pen and place your hand in position to write, but do not begin to write until I say 'Start.' Then all begin at once. When I say 'Stop' I want you all to stop at once and raise your hands so that I can see that you have stopped."

Now take your watch in hand and when the second-hand reaches the *55* second mark say, "Get ready." Exactly at the 60 second mark say, "Start." At the end of three minutes call out, "Stop, hands up." Be sure to allow exactly three minutes. Have each child write name and age on the *back* of the paper. Collect the samples at once and put them together.

I

5 10 15
Mary had a little lamb,
20 25 30 35 40
Its fleece was white as snow;
45 50 55 60 65
And everywhere that Mary went
70 75 80 84
The lamb was sure to go.

II

5 10 15 20 25
He followed her to school one day;
30 35 40 45
That was against the rule;
50 55 60 65 70 75
It made the children laugh and play
80 85 90 95 97
To see the lamb in school.

III

5 10 15 20 25
And so the teacher turned him out,
30 35 40 45
But still he lingered near,
50 55 60 65 70
And waited patiently about
75 80 85 80
Till Mary did appear.

Directions for securing samples for the "Gettysburg Edition" of the Ayres Scale. With the "Gettysburg Edition" of his handwriting scale Ayres gives directions which should be followed when that scale is used. The directions are not entirely complete and should be supplemented by the last two paragraphs of the directions given above.

To secure samples of handwriting the teacher should write on the board the first three sentences of Lincoln's *Gettysburg Address* and have the pupils read and copy until familiar with it. They should then copy it, beginning at a given signal and writing for precisely two minutes. They should write in ink on ruled paper. The copy with the count of the letters is as follows:

Four 4 score 9 and 12 seven 17 years 22 ago 25 our 28 fathers 35 brought 42 forth 47 upon 51 this 55 continent 64 a 65 new 68 nation 74 conceived 83 in 85 liberty 92 and 95 dedicated 104 to 106 the 109 proposition 120 that 124 all 127 men 130 are 133 created 140 equal 145. Now 148 we 150 are 153 engaged 160 in 162 a 163 great 168 civil 173 war 176 testing 183 whether 190 that 194 nation 200 or 202 any 205 nation 211 so 213 conceived 222 and 225 so 227 dedicated 236 can 239 long 243 endure 249. We 251 are 254 met 257 on 259 a 260 great 265 battlefield 276 of 278 that 282 war 285.

Other selections which have been used. Different investigators have required pupils to write different material. Several have used the first line or the first stanza of the poem "Mary had a little lamb," which is reproduced above. "Sing a song of sixpence" has been used. Other sentences which have furnished copy are: "Jolly kings bring gifts while happy maids dance." "A quick brown fox jumps over the lazy dog." [1] "Then the carelessly dressed gentleman stepped lightly into Warren's carriage and held out a small card. John vanished behind the bushes and the carriage moved along down the driveway." [2]

[1] This sentence was used in securing specimens for the Freeman Scale. It contains all of the letters of the alphabet.

[2] These sentences were used in securing the specimens for the Thorndike Scale.

In the Cleveland Survey the first three sentences of Lincoln's *Gettysburg Address* were written, and Ayres has used this selection in the "Gettysburg Edition" of his scale. In several school surveys the pupils were allowed to write any familiar stanza of a poem. The chief principles to bear in mind in selecting materials are: (1) to use material in the lower grades which will not furnish difficulties in spelling and remembering; and (2) to use material which will be uniform in all classes which are to be compared.

Marking the papers for rate of handwriting. Time can be saved by making use of the numbered selections given above. Divide the total number of letters written by the number of minutes allowed. The quotient is the number of letters per minute. This is the pupil's rate score and should be written in the upper right-hand corner of his paper.

Measuring the quality of handwriting by means of scales. The "quality" of a sample of handwriting may be measured by means of a "handwriting scale" which consists of a number of specimens of handwriting arranged in order of "quality." The process of measurement simply consists of moving the sample which is being measured along the scale until a specimen of the scale is found which "matches" it in "quality." The process is much like "matching" a sample of dress material or ribbon. Skill in this "matching" or use of the scale comes with practice and it is recommended that a teacher prepare himself by at least a short period of training.

Handwriting scales. The scales in most general use are the ones constructed by Thorndike[1] and by Ayres.[2]

[1] Thorndike, E. L., "Handwriting"; in *Teachers College Record* (March, 1910), vol. 2, no. 5. The scale may be purchased from the Bureau of Publications, Teachers College, Columbia University, New York City.

[2] Ayres, L. P, *A Scale for Measuring the Handwriting of School-Children.* (Russell Sage Foundation, Bulletin 113.) Ayres has also constructed an adult scale and the "Gettysburg Edition." In this book the term "Ayres Scale" refers to the "Gettysburg Edition" unless otherwise [illegible]

Thorndike constructed his scale on the basis of three characteristics — beauty, legibility, and general merit. The degree of these characteristics represented in the specimens of the scale was determined by the consensus of opinion of competent judges. Ayres constructed his scale on the basis of legibility alone. He defined legibility in terms of ease of reading. That specimen was defined as most legible which was read most easily. The numerical values of the specimens of the Thorndike Scale range from 4 to 18, one or more specimens being given for each degree of quality.

Ayres's Scale, "Three-Slant Edition," consists of three types of specimens, vertical, semi-slant, and full slant. Each of these three types is represented by eight degrees of quality to which are assigned the numerical values 20, 30, 40, up to 90. In using this scale it must be remembered that these values are not the same as the per cents used in reporting "grades."

Ayres[1] later devised a scale from specimens of handwriting written by adults. Trained judges used the "Three-Slant Edition" in selecting the specimens and in determining their values. This "Adult Scale" is similar to the "Three-Slant Edition" in its general plan. Very recently (1917) Ayres devised a third scale, the "Gettysburg Edition." This scale differs from the others in the following particulars: It has one specimen for each step. The specimens are written on ruled paper. The copy is the same for all specimens. In addition to the specimens of the scale. this edition has directions for securing specimens from a class and for scoring these specimens. It also furnishes standards for rate and quality of handwriting for the grades above the fourth. Ayres asserts that the purpose of these changes is "to increase the reliability of measurements of hand-

[1] Ayres, L. P., *A Scale for Measuring the Handwriting of Adults.* (Russell Sage Foundation, Bulletin E 138.)

writing." A recent investigation[1] shows that measurements made by this scale are more reliable than when made by the "Three-Slant Edition."

Following discussion based on the "Gettysburg Edition" of Ayres's Scale. Because more reliable measurements may be obtained by using the "Gettysburg Edition" of Ayres's Scale, we shall base the following discussion upon it. It will, however, be an easy matter for any one to adapt it to any other scale. In order to understand the following pages the teacher should have a copy of this scale. See the Appendix for price list and directions for securing a sample package of tests.

Training in the use of a handwriting scale. The accuracy of a teacher's measurements of quality handwriting depends upon the method he uses and upon his training in the use of that method. When a teacher is using a handwriting scale for the first time the following preliminary exercise is recommended:

Select ten samples at random. Number these samples and place their numbers on a blank sheet of paper. Now take the first sample and rate it thus: Place the Ayres Scale on a table in full view and in a good light. Place the sample directly under the scale division marked 20 and move it along toward 90, comparing it with each division. Decide which division of the scale it resembles most in quality. "Disregard differences in *style*, but try to find on the scale the *quality* corresponding with that of the sample being scored." Then place it under the scale division marked 90 and work back toward 20 as before. Decide again which division it resembles most in quality. If your two judgments agree, mark the rating on the blank paper opposite the numeral 1. If the two judgments do not agree, compare the sample again with the two divisions of the scale and determine which it most nearly resembles. Proceed to rate the other samples in this manner, keeping the record for

[1] Breed, F. S., "The Comparative Accuracy of the Ayres Handwriting Scale, Gettysburg Edition"; in *Elementary School Journal* (February, 1918), vol. 18, p. 458.

each. When you have finished the ten samples, lay this record aside, out of sight. Rate the ten samples a second time, again keeping the records and again laying the records aside. Do this a third time, and when you have finished, compare your three ratings for each of the ten samples. If the three ratings for any one sample vary more than ten, satisfy yourself as to which rating is the correct one, by comparing it with the scale again.

When convenient it is better to use samples whose correct rating is known. A set of fifty such samples may be obtained from the Bureau of Publications, Teachers College, Columbia University, New York City. They are rated in terms of Thorndike's Scale, but these scores can be changed to Ayres's Scale by multiplying by 6.7 and subtracting 20 from the product. The remainder is the true quality of the sample on the Ayres Scale.

Method of using the scale. For using the "Gettysburg Edition" Ayres gives the following directions:

To score samples slide each specimen along the scale until a writing of the same quality is found. The number at the top of the scale above this shows the value of the writing being measured. Disregard differences in *style*, but try to find on the scale the *quality* corresponding with that of the sample being scored. With practice the scorer will develop the ability to recognize qualities more rapidly and with increasing accuracy. If the scoring is done twice, the results will be considerably more accurate than if done only once. The procedure may be as follows: Score samples and distribute them in piles with all the 20's in one pile, all the 30's in another, and so on. Mark these values on the backs of the papers, then shuffle the samples and score them a second time. Finally make careful decisions to overcome any disagreements in the two scorings.

Whenever three or more persons can work together in scoring specimens the results may be expected to be more satisfactory than those secured by independent work. All the members of the group should examine the specimen of writing and confer concerning the rating it should receive.

A majority of the group must agree before a score is assigned to the specimen.

A method which will require more time, but one which will secure more accurate results than the methods described above, is one in which a group of three or more persons score the specimens independently, using the sorting method. Then the scores assigned by all of the judges to a specimen are averaged and the result taken as the true score for that specimen. The accuracy of the resulting scores will increase with the size of the group of judges.

Recording scores. After the samples are rated the teacher must be careful that his papers are grouped correctly by classes. If he has but one grade of pupils, say fifth grade, or two divisions of the same grade, say fifth A and fifth B, then his papers may be all grouped together and but one distribution made. If, however, he has parts of two or more grades, say part fifth and part sixth, he must fill out a separate record sheet for each division. A convenient form of a class record sheet is shown in Fig. 30.

Sort the papers from one class on the basis of quality. (For instance, put into one pile all those papers having a quality of 90, into another put all the 80's, into another all the 70's, and so on.) Then, one pile at a time, re-sort the papers in each of these piles on the basis of their score for rate, placing together those papers whose rates are 30 to 39, 40 to 49, 50 to 59, etc. (For example, if there were ten papers of quality 60, whose rates were 50, 53, 55, 62, 62, 64, 69, 72, 77, 80, the first three would be piled together, the next four would form a second pile, the next two a third pile, and the last one would be placed by itself.) Next count the number of papers in each of these piles and record the numbers in the proper vertical column of the table. (In our illustration this is the column under 60. There are three papers in the pile whose rates are between 50 and 59. Place

a figure 3 in the 60 column and directly opposite the numerals 50 to 59. There are four papers in the pile whose rates are 60 to 69. Hence, a figure 4 is to be placed in the 60 column and opposite the numerals 60 to 69.) Each of the other piles is to be treated in the same way.

When all the scores have been entered, find the sum of the figures in each vertical column and in each horizontal row. If your records have been accurately made, the sum of the horizontal totals will just equal the sum of the vertical totals. Save all specimens for future use.

Computing class scores. The medians of the distributions (rate and quality) are used to designate the general standing of a class. The method of calculating the median, described on page 103, is used. It is necessary to remember that in the record sheet shown on page 213, the width of the intervals is 10, the same as in the accuracy distributions for arithmetic. When there are fewer than fifteen pupils in a class it is not wise to attach much importance to the medians. The distributions and individual scores are more significant.

Measurement for diagnosis. The quality of a sample of handwriting is a complex product. It depends upon several characteristics of the handwriting, such as the uniformity of slant, uniformity of alignment, letter formation, and spacing. There are available two instruments for diagnostic measurement:

1. Freeman's[1] *Scale* which differs from the other scales in an important respect. It is in reality five scales, one for each of the following characteristics of handwriting: uniformity of slant, uniformity of alignment, quality of line, letter formation, and spacing. These five scales are now printed

[1] Freeman, F. N., *The Teaching of Handwriting.* (Houghton Mifflin Company, 1915.) Also, "An Analytical Scale for the Judging of Handwriting"; in *Elementary School Journal* (April, 1915), vol. 15, p. 432. A copy of the scale can be obtained from Houghton Mifflin Company, Boston.

DISTRIBUTION OF PUPILS' SCORES

Number of letters written in one minute	*Quality*								*Total for rate*
	20	30	40	50	60	70	80	90	
Below 10									
10 to 19									
20 to 29									
30 to 39									
40 to 49									
50 to 59									
60 to 69									
70 to 79									
80 to 89									
90 to 99									
100 to 109									
110 to 119									
120 to 129									
130 to 139									
140 to 149									
Over 150									
Total for quality									

Approximate Class Medians: Quality.................... Rate (Letters per min.) ....
True Medians: Quality.................... Rate (Letters per min.)..........

FIG. 30. SHOWING FORM OF CLASS RECORD SHEET FOR RECORDING SCORES IN HANDWRITING

on one sheet of paper or chart, and each scale is called a division.

The first of the five divisions of the Freeman Scale represents three degrees of uniformity of slant. In using this division, as in using the next division, judgments will be made more easily if a slant and alignment gauge is used.[1] The second division represents uniformity of alignment. The user must be careful to note that letters which are close together show deviations in alignment more prominently than letters written farther apart.

The third division shows the quality of line or stroke. A reading-glass will aid in judging with this division. The fourth division is intended to measure letter formation. Freeman describes eight illegible forms of letters which should be counted as errors. Two principles should control here: (1) whatever slant or type of script the pupil may use, consistency to that choice should be maintained; and (2) no letter should vary from its recognized form so much as to be easily mistaken for another letter. The fifth division shows different kinds of spacing. Letters may be crowded or spread too far apart. The same applies to words.

In each division the three degrees of excellence are given scores of 1, 3, and 5 respectively. The intermediate values of 2 and 4 may also be used. If the old edition of the scale is used, the scores assigned to the specimens of letter formation are 2, 6, and 10. Freeman suggests that the specimens be scored by using the score for letter formation as placed on the new edition of the chart, and then doubling these scores in making up the total score.

[1] Freeman, F. N., *The Teaching of Handwriting*, p. 151. The slant gauge consists of three rows of parallel lines. The lines in one row are vertical and in each of the other rows the lines are set at a uniform slant. The alignment gauge consists of one straight line four or five inches long. These lines may be drawn on transparent paper and placed over a specimen of handwriting to assist in determining the deviations from uniformity in slant and alignment.

Using the Freeman Scale. This scale may be used for measuring specimens from all members of a class, but frequently it is used to measure specimens written by those ranking conspicuously below the average ability or below the standard ability for the class. This needy group of pupils may be selected by the teacher's unaided judgment, but preferably by the use of the Thorndike or Ayres Scale.

Freeman [1] has recently issued the following suggestion for using his scale:

> The specimen to be judged is graded according to each category separately and given the rank of the specimen in the chart with which it most nearly corresponds in each case. The total rank is calculated by summing up the five individual ranks. Thus, if letter formation is given double value, the lowest possible rank is 6 and the highest possible rank is 30 (5 + 5 + 5 + 10 + 5), and the range is 24.
>
> Several precautions are to be observed in making the judgments. The value of the method rests upon the fact that different features of the writing are singled out, one at a time, and graded by being given a rank in one of only three steps. The difference between the steps are marked, and the ease of placing a specimen should be correspondingly easy.
>
> This method implies, however, that
>
> (1) The attention is fixed on only one characteristic at a time.
> (2) The judgment on one point be not allowed to influence the judgment on the other point.
> (3) The same fault be counted only once.
> (4) General impressions be disregarded.

The scores secured by means of the Freeman Scale should be saved to furnish a means of evaluating the results secured from instruction. The scores may be recorded on the specimen, or, better, on an individual record card, such as shown in Fig. 31. The latter will be more convenient when the

[1] Freeman, F. N., *Experimental Education*, p. 86. (Houghton Mifflin Company, 1916.)

Pupil's Name......................*City*..................

	First trial *Date*.......	*Second trial* *Date*.......	*Third trial* *Date*......	*Fourth trial* *Date*......	*Teacher*........ *Grade*........ *Age*........ *Building*........
Chart I (Slant)					
Chart II (Alignment)					
Chart III (Quality of line)					
Chart IV (Letter formation)					
Chart V (Spacing)					
Total (value on Freeman Scale)					
Quality (value on Ayres Scale)					
Speed (Letters per minute)					

FIG. 31. INDIVIDUAL RECORD CARD, FREEMAN SCALE.

teacher wishes to examine a series of scores recorded at intervals over a term of several months.

2. Gray's Score Card for detailed analysis. The score card represents another attack upon the problem of measurement. It requires that the essential elements of handwriting be selected and each assigned a value. The score card devised by Gray [1] weights the value of each of the essential elements of handwriting so that the highest value which can be assigned to slant is 5, while spacing of letters may receive 18, neatness, 13, etc. (See Fig. 32.) The use of this score card by teachers in their grading of handwriting would undoubtedly tend to direct their attention to the individual needs of the pupils. So far there is no evidence to show that its use will result in more accurate measures than the use of any one of the scales. Some claim that

[1] Gray, C. Truman, *A Score Card for the Measurement of Handwriting.* (Bulletin of the University of Texas, no. 37, July, 1915.)

Pupil.......................... *Age*................ *Date*.........................
Grade................................... *School*............................ ......
Sample Number............... *Teacher*...

Sample	*Perfect score*	*Score*													
		1	2	3	4	5	6	7	8	9	10	11	12	13	14
1. Heaviness..............................	3														
2. Slant................................. Uniformity Mixed	5														
3. Size................................. Uniformity Too large Too small	7														
4. Alignment..........................	8														
5. Spacing of lines...................... Uniformity Too close Too far apart	9														
6. Spacing of words Uniformity Too close Too far apart	11														
7. Spacing of letters.......... .... Uniformity Too close Too far apart	18														
8. Neatness.............................. Blotches Carelessness	13														
9. Formation of letters..................	(26)														
General form	8														
Smoothness...........................	6														
Letters not closed.....................	5														
Parts omitted........................	5														
Parts added..........................	2														
Total Score....................	..														

FIG. 82. STANDARD SCORE CARD FOR MEASURING HANDWRITING. (*Devised by C. T. Gray.*)

the elements of handwriting have not been correctly evaluated. However, it has the advantage that its use trains the user in the analysis of handwriting. Gray well defends the device by saying that agriculturists have long used

such score cards to secure very satisfactory and accurate results in judging grain and live-stock.

In using Gray's Score Card and the Freeman Scale, measures of each of the several factors concerned in a pupil's handwriting are secured. A record of successive measurements will show just what abilities have not been sufficiently improved. These abilities will then be the points of attack for the teacher and pupil in their subsequent work. For example, a record as shown on the Gray Score Card might indicate that a pupil's handwriting was suffering chiefly because of poor letter formation. A closer inspection would show that letter formation was very often defective in two items, letters not closed and parts omitted. Such diagnosis reveals a definite problem for the teacher.

Use of the score card. The score card (see page 217) may be used for a pupil, or a class. If it is used for a pupil, the numerals along the top may be taken to indicate weeks, months, or other intervals. In the column under the numeral 1 the first scores of a pupil's handwriting should be entered. A month later a second series of scores should be entered in the column headed by the numeral 2. The next month another series of scores should be entered under numeral 3, and so on. At the close of a term there will appear a very useful record of the child's experience in the learning of handwriting. This use of the score card Gray calls a clinical study.

If the card is used for a class, the numerals at the head of the columns stand for the specimens written by the several pupils of the class. The totals at the bottom will furnish an interesting comparison of the ability of the pupils. Each pupil knowing his number can tell how he stands in relation to the other members of the class. If a new score card is posted each month, a pupil may see whether he is gaining

or losing in his position in the class. If he is losing, he will be inclined to seek the reason. He may see that his neatness has a low score. This furnishes a strong incentive for work to improve in neatness. Teachers and supervisors might compare their records. The use of the card may be varied by training pupils to score their own or others' handwriting, or by one teacher calling on another teacher to score the handwriting of his pupils.

Standards. In Table XXII we give (1) standards proposed by Ayres for his "Gettysburg Edition"; (2) standards proposed by Freeman; and (3) "the Kansas Medians" which were obtained by using the directions given on page 204. Table XXII is read thus: A second-grade class should have a median score for rate of 36 letters per minute, and a median score for quality of 44, when scored by the Ayres Scale. A third-grade class should have a median quality of 47 and a median rate of 48 letters per minute. The standards for the other grades are read in the same manner.

TABLE XXII. HANDWRITING STANDARDS — RATE IN LETTERS PER MINUTE — QUALITY IN TERMS OF THE AYRES SCALE

	School grades						
	II	III	IV	V	VI	VII	VIII
Freeman standards —							
Quality	44	47	50	55	59	64	70
Rate	36	48	56	65	72	80	90
Ayres ("Gettysburg Edition") —							
Quality	38	42	46	50	54	58	62
Rate	32	44	56	64	70	76	80
Kansas medians —							
Quality	44	47	50	55	59	64	70
Rate	32	35	51	61	67	71	73

Ayres's standards represented graphically. Ayres has represented graphically his standards for the "Gettysburg Edition" as shown in Fig. 33. Quality is represented on the horizontal lines and rate on the vertical. The positions of the small circles indicate the standards for the respective grades. This plan of graphical representation is frequently helpful in interpreting the scores of a class or of a school.
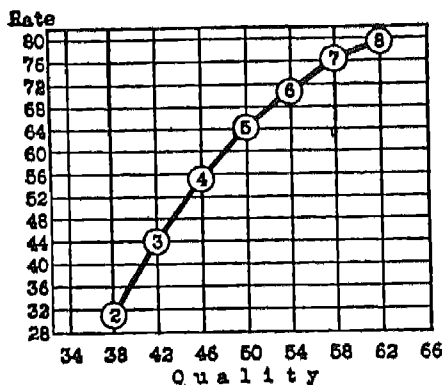
FIG. 33. GRAPHICAL REPRESENTATION OF AYRES'S STANDARDS FOR THE "GETTYSBURG EDITION" OF HIS HANDWRITING SCALE

The basis of satisfactory standards in handwriting. The standards of attainment are determined by two considerations: (1) they must be attainable by pupils under ordinary school conditions, and without the expenditure of an unreasonable amount of time and effort; (2) they should be high enough to assure that the pupil will have sufficient skill in writing to meet the demands which will be made upon him. These considerations are emphasized by the facts that only a limited amount of time is available for the teaching of handwriting in the ordinary school, and that after practice has progressed for a time, it does not bring as large returns as it did in its initial period.

The first of these considerations has been met by examining the handwriting of thousands of children, gathered from all parts of our country. Freeman used the results of the

scoring of about five thousand specimens from each of the seven grades. These specimens were selected from a large number of specimens which were collected in fifty-six large cities of the United States. He found that the average of the scores of the upper half of these specimens gave scores for rate and quality which are approximately the standards he proposes. In checking up the second consideration, Freeman investigated the demands which are made upon those who are employed in several large commercial houses. The returns from this investigation, together with the results of the other investigation, indicated that the standards as proposed are but little more than the minimum essentials. Moreover, Freeman estimates on good evidence that these standards can be attained with an expenditure of not over seventy-five minutes a week.

Standards required for practical work. Pupils are taught to write for two reasons: (1) in order to be able to meet the practical demands for writing outside of school, and (2) in order to be able to do the writing that is required in school, particularly in high school and college. Eventually these demands will determine the standards for both rate and quality. With reference to quality Ayres[1] and Ashbaugh[2] have drawn certain conclusions from the requirements in handwriting which are set up by the examiners of the Municipal Civil Service Commission of New York City. Ashbaugh quotes a letter from the Acting Director of the commission as follows:

> I find that the Municipal Civil Service Commission of New York ordinarily uses the standard of 70 per cent as a passing grade in handwriting, but for positions where handwriting is a special requirement the standard is sometimes set at 75 per cent.

---

[1] Ayres, L. P., *A Scale for Measuring the Quality of Handwriting of Adults.* (Russell Sage Foundation, Bulletin E 138.)

[2] Ashbaugh, Ernest J., *Handwriting of Iowa School Children.* (Bulletin of the University of Iowa, March 1, 1916.)

Ayres has shown that the ratings of 70 per cent and 75 per cent, as given by the commission, correspond respectively to scores of 40 and 50 on the Ayres Scale. Since this commission recommends many persons who cannot write better than the 40 specimen of the Ayres Scale, and recommends others who write only as well as the 50 specimen, for positions where handwriting is a special requirement, it would follow that an ability to write as well as 50 on the Ayres Scale would be sufficient for all the demands which most pupils will meet.

Koos[1] has recently reported a study of the non-vocational handwriting of 1053 persons and also the handwriting of several vocational groups. He states his conclusions as follows:

> To write better than 60 is to be in a small minority (13.5 per cent of 1053 cases) as concerns handwriting ability. Moreover, four-fifths of 826 judges consider the quality 60 adequate with a generous majority approving quality 50. In the light of these facts, *it is difficult to see why, for the use under consideration (non-vocational correspondence) a pupil should be required to spend time to learn to write better than quality 60. There is even considerable justification for setting the ultimate standard at 50. As this demand touches every member of society, all children in the schools should be required to attain the standard set.*
>
> From the facts that have been presented touching the ability in handwriting of persons engaged in various occupations, it seems to the writer that *the quality 60 on the Ayres Measuring Scale for Adult Handwriting . . . is adequate for the needs of most vocations. . . . For that large group who will go into commercial work, for telegraphers, and for teachers in the elementary schools it will be necessary to insist upon the attainment of a somewhat higher quality, but hardly in excess of the quality 70.*

Standards required for school work. We have but little data on this point, but many pupils come to high schools

[1] Koos, L. V., "The Determination of Ultimate Standards of Quality in Handwriting for the Public Schools"; in *Elementary School Journal* (February, 1918), vol. 18, p. 422.

unable to write rapidly enough for the demands placed upon them. They then often sacrifice the quality of their handwriting for the sake of greater rate. Lewis[1] examined the hand-writing of 1760 third- and fourth-year students of 166 Iowa Normal Training High Schools. He found their median score for quality to be 59.1 on the Ayres Scale, with a range from 34 to 89. Fifty per cent of the scores fell between 53.6 and 64.3. The average rate of their handwriting was 90 letters per minute. Thus, they rank with the seventh-grade standard for quality, and the eighth-grade standard for rate. Comparing their scores with those of eighth-grade children (see Table XXII), these high-school pupils write from ten to fifteen letters per minute faster, but no better than the average eighth-grade pupil. These data bear out the statement that the higher schools require greater rate of handwriting than the training of the elementary schools have furnished. Therefore, increased emphasis should be placed upon rate in teaching handwriting.

Summary. This discussion of standard scores for handwriting may be summarized by saying that there is evidence that the standards for quality given in Table XXII may be slightly higher than they should be, particularly those given by Freeman. The standards given by Ayres may be considered satisfactory. In the case of the rate of writing Freeman's standards are probably the best.

Types of situations revealed by the measurement of handwriting ability. Three types of situations which need corrective instruction may be recognized: (1) the median rate of writing is below standard; (2) the median quality is below standard; (3) the scores are too widely scattered.

Type I. Below standard in rate of writing: The Cause.

[1] Lewis, E. E., "The Present Standard of Handwriting in Iowa Normal Training High Schools"; in *Educational Administration and Supervision* (December, 1915), vol. 1, pp. 663–71.

Fig. 34 represents the distribution of scores for a third-grade class. The numerals along the bottom of the figure denote quality on the Ayres Scale, and the rate in terms of letters written in one minute. The numerals along the side indicate the number of pupils. A perpendicular solid line shows the location of the median for the class, and a perpendicular broken line shows the location of the standard
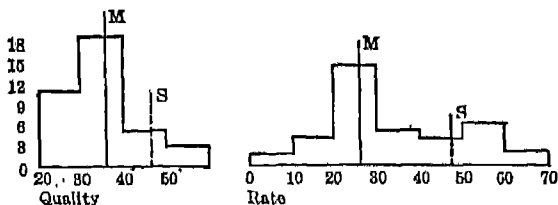
Fig. 34. Showing the Distribution of Scores in Handwriting of a Third-Grade Class.

The line M indicates the median score for the class, the line S the standard for the class.

for that grade. This class is below standard in both rate and quality. The quality will be considered under Type II. When the median rate of writing of a class is conspicuously below standard, as is the case of the third-grade class shown in Fig. 34, it is almost certain that the teacher is failing to place sufficient emphasis upon rate in his instruction. The author has found teachers and even supervisors of handwriting who admitted that they had given no attention to the rate of writing, but it was obvious that rate was important as well as quality. A few pupils are very slow in their movements, and this may account for the low rate of individual pupils, but not for a low median score except in very unusual cases.

The corrective. In considering corrective instruction for a class whose median rate score is below standard, it is neces-

sary to bear in mind the relations which exist between rate, movement, rhythm, and quality. Investigation[1] has shown that the kind of movement, finger, arm and finger movement combined, or arm movement, does not affect the rate of writing when it is carried on for only a short time as is the case in the measurement of ability in handwriting. The apparent greater ease of production of arm or muscular movement may result in greater rate if rate is measured during a long period of writing.

Nutt has recognized what he calls "rhythm." This is a quality or characteristic of the movement. It increases with age, but has no relation to amount of arm movement or to the quality of the writing. Nutt found that rate of writing and rhythm increase together; that is, children who score high in rhythm also score high in rate, but may not use arm movement or produce a better quality of handwriting than other children.

Relation between rate and quality. Several studies have sought for a relation between rate and quality of handwriting. In the Cleveland Survey[2] it was found that "in general speed and quality vary inversely. But there is a middle series of speeds and qualities where improvement in one does not seem to interfere with the other"; that is, outside of the limits which are approximately those of the proposed standards, efforts to secure an unusual degree of quality will reduce the rate, and *vice versa*. Several investigations of adults' handwriting show that they tend to increase the rate and reduce the quality. A general view of the results bearing on this point shows that the children who write a good quality on the average write as rapidly as those who write a poorer quality. This seems to be due

[1] Nutt, H. W., "Rhythm in Handwriting"; in *Elementary School Journal*, vol. 17, pp. 432–45.

[2] Judd, C. H., *Measuring the Work of the Public Schools*, pp. 80–81.

to the natural rhythm of the children. If this rhythm is forced or disturbed unduly the quality suffers. Thorndike's results indicate that causing a pupil to write more slowly than his normal rate did not improve the quality of the handwriting.

Drills for increasing the rate of writing. Since within limits the rate of writing may be increased without seriously disturbing the quality, it will be possible in some cases to bring the median rate up to standard by rate drills in which the pupils are caused to write at standard rates. A convenient device for doing this is represented by the following example. This is a dictation exercise arranged for the sixth grade. The rate of dictation which is indicated by the numbers printed above the words is based upon Freeman's standards. (See page 219.) The teacher should direct the class to be ready to write, then, watching the second-hand of his watch, until it is at 60, start to dictate. A little preliminary practice will make it easy to dictate the words so that they will be pronounced as indicated. For example, the teacher should be pronouncing the word "care" just before the second-hand reaches the ten-second mark, etc.

Do [5] you take care [10] to keep your teeth [20] very clean, [30] by washing them [40] without failing [50] every morning [60] and after every meal? [15] This is [20] very necessary [30] both to preserve [40] your teeth [50] a great while, [60] and to save you [10] a great deal of pain. [20] (Stop.)

At first a class will not be accustomed to this form of exercise and may not respond in a satisfactory manner, but a little patience on the part of the teacher will soon eliminate such temporary confusion. The rate of a class which is far below standard should be gradually increased. For example, if the sixth-grade class is below the fourth-grade

standard, a dictation exercise arranged for the fourth grade should be used. When the class is able to respond to this satisfactorily, the dictation exercise for the fifth grade should be used and later the one for the sixth grade.

If the quality of the handwriting of certain pupils decreases because of such drills, these pupils should be excused from them or a different type of drill used. The following is a modification which will be helpful in such cases; the sentence, "The quick brown fox jumps over the lazy dog" contains thirty-five letters.

8th-grade	pupils	should	write	this	11	times	in	4	min.		
7th	"	"	"	"	"	8	"	"	3	"	30 sec.
6th	"	"	"	"	"	6	"	"	3	"	
5th	"	"	"	"	"	5	"	"	2	"	45 "
4th	"	"	"	"	"	4	"	"	2	"	30 "
3d	"	"	"	"	"	3	"	"	2	"	10 "
2d	"	"	"	"	"	2	"	"	2	"	

The pupils should memorize the sentence and write it several times for practice and for spelling. The teacher should then time their writing. Those who do not write the required number of letters in the allotted time, as given in the table above, should be told to write faster, until they have done the test successfully.

Developing rhythm. If such exercises as described above reveal a serious sacrifice in the quality when the rate is increased, or if the pupil's handwriting cannot be brought up to standard rate, we may consider that the pupil's rhythm has not developed to the place where it will sustain this rate. Since we do not know which is the primary factor, rhythm or rate, the best procedure would be to seek to develop both. Rhythm may be increased by the use of music. If the school owns a phonograph, records suitable for use in penmanship classes may easily be secured. The time of the music may be adjusted to the grade. Careful

attention to the securing of a free, well-relaxed hand position will aid in securing rate. Sometimes a careful analysis of letter forms will reveal that the pupil is forming some letters in a way that makes a satisfactory rate impossible. In such cases new forms of those letters should be taught.

Type II. Below standard in quality of writing. This condition may occur along with an unsatisfactory rate, as in Fig. 34, or when the rate is up to or above standard. In attempting to increase the median quality of the handwriting of a class, methods and devices used should be selected in the light of facts which have been established by investigations of the learning process,[1] as it occurs in learning to write. There are not sufficient data from comparative studies of different penmanship systems to establish any single system as superior to others in its effectiveness to secure results in terms of rate and quality of handwriting. Hence, the corrective to be sought is not some system of writing which is a panacea for all handwriting troubles.

General laws of learning applied. The ability to write well is a habit; hence, the laws of habit formation apply to the acquisition of this ability.

The *first* essential factor is a right start. The pupil must have a clear view of the habit to be acquired. This may mean a definite idea of the movement to be executed, or a picture of the letters or series of letters which are to be made. The start must be made with a strong initiative. Sometimes the pupil must be shocked into a desire to correct a fault of his handwriting.

The *second* essential is that of attentive repetitions. The

[1] No attempt is made to review or to criticize the material which appears in numerous manuals of handwriting. Much excellent material which appears in *The Teaching of Handwriting*, by Freeman, is not even mentioned, because of lack of space. The difficulty of confining this discussion to the actual facts discovered through measurement of handwriting will be apparent.

repetitions or drills should be strongly motivated. All investigations of habit formation agree upon this point. The periods of practice are most efficient if not carried to the point of fatigue; hence, for the lower grades Freeman suggests frequent ten-minute periods of practice. In no grades should the periods be longer than twenty minutes.

The *third* step, as often stated, is, "Allow no exceptions to occur." If a pupil practices correct form in the penmanship class for ten minutes, and then uses poor form in a spelling class for the same length of time, the latter exercise will tend to cancel the effects of his practice in the penmanship class.

A *fourth* step is the repetition of the habit until it is well fixed. This means that the repetitions must extend beyond the point of apparent completion to permanent automatism. After this stage is reached, incentives should be found which will raise the habit from the level of mere automatism to higher levels of skill.

Motivating practice. A number of devices and plans have been proposed for the motivation of practice in correcting faults in quality of handwriting. Wilson[1] gives the result of an interesting experiment in which the Thorndike Scale was used in such a way that the students could follow their own progress in handwriting. In this case each student was competing with his own record. Several teachers have constructed scales from the specimens collected in a school or class. These scales may be constructed by rating the specimens with any one or more of the scales described. Superintendent Bliss of the Montclair, New Jersey, schools is quoted by Wilson as follows: "A scale made from the writing of pupils makes a stronger appeal than either the Ayres or Thorndike Scales." A scale, either one made from

[1] Wilson and Wilson, *The Motivation of School Work* (Houghton Mifflin Company, 1916), p. 187.

specimens collected in the school or one of those described on page 208, should be posted in the schoolroom and pupils encouraged to compare their handwriting with it frequently. For this purpose the Ayres Scale is most convenient.

Charters[1] recommends a "writing hospital" to which the poor writers are sent until they are properly convalescent. This hospital is a special penmanship class. Stone[2] has a plan which puts all the pupils of a school in four groups for their writing lessons. These are groups 1, 2, 3, and the excused group. The special feature of this plan is that at stated intervals members of a lower group are allowed to challenge members of a higher group, and a contest for the coveted place ensues.

Many special devices for motivation are in use. Pupils write letters ordering supplies for the school, or they write invitations to school parties, pageants, etc. Some pupils write letters for the teacher or principal.

Fig. 35. Showing the Distribution of Scores in Handwriting of Fourth-Grade Class

The line M indicates the median score for the class, the line S the standard for the class.

Type III. Scores too widely scattered. The scores of a fourth-grade class of this type are shown in Fig. 35. As in the case of other school subjects, the pupils who are grouped together in any school grade will be found to differ widely

[1] Charters, W. W., *Teaching the Common Branches*. (Houghton Mifflin Company, 1916.)

[2] Stone, C. R., "Motivation of the Formal Writing Lesson Through a Special Classification of Pupils for Writing"; in *School and Home Education*, June, 1915.

in both rate and quality. However, these differences should be reduced to a minimum. Fig. 36 represents the scores of a fifth-grade class which exhibits what probably should be regarded as a satisfactory condition. The differences between the members of this class are much less than those of the class shown in Fig. 35.
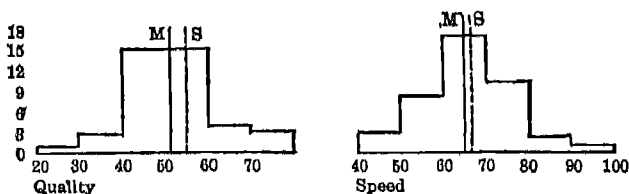
FIG. 36. SHOWING THE DISTRIBUTION OF SCORES IN HANDWRITING OF FIFTH-GRADE CLASS

The line M indicates the median score for the class, the line S the standard for the class.

In connection with his "Gettysburg Edition," Ayres has given standard distributions for the four upper grades. These are reproduced in Fig. 37. The teacher may use them to ascertain whether or not the scores of his class are too widely scattered.

Correctives. The reduction of a high degree of individual differences is largely a matter of dealing with individual pupils. A reclassification may be wise where it is possible, but for the most part the classification of pupils is determined by their standing in other subjects. Those pupils who are distinctly above the eighth-grade standard should be excused from the penmanship class. They may spend the time thus saved upon other subjects. Dictation exercises, such as described on page 226, will tend to reduce the degree of individual differences in rate of writing.

Diagnostic measurements. In the case of pupils who are below standard in quality, it is helpful to diagnose their

Rate of writing. Columns represent per cent of pupils in each of four upper grades commonly found to write the number of letters per minute shown below each column.

Quality of writing. Columns represent per cent of pupils in each of four upper grades commonly found to have handwriting of qualities shown below each column.
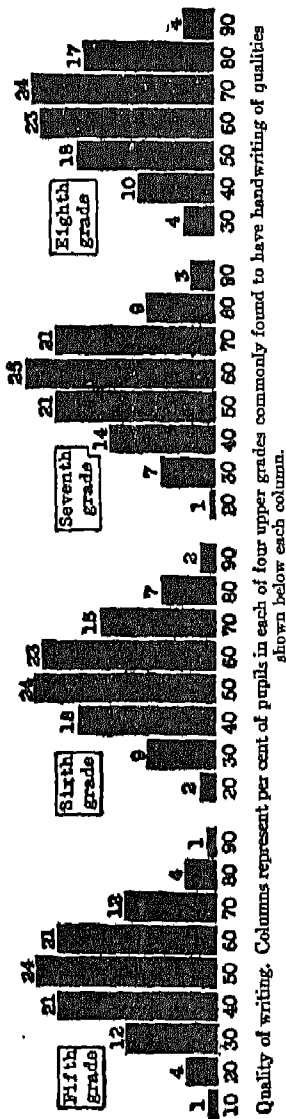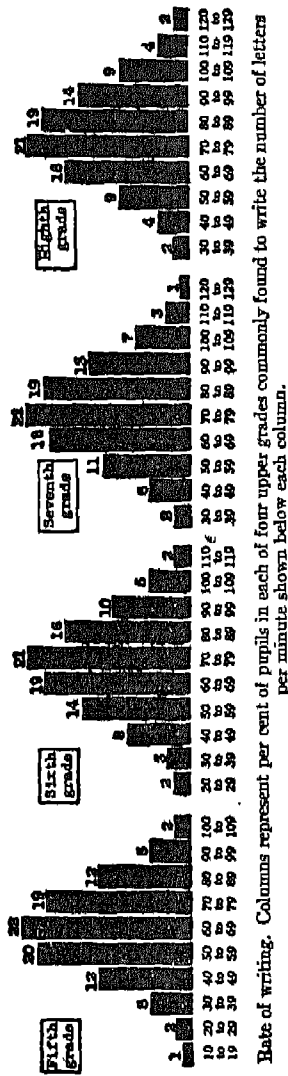
FIG. 87. SHOWING STANDARD DISTRIBUTION OF SCORES IN HANDWRITING. (*After Ayres.*)

handwriting using either Freeman's Scale or Gray's Score Card. This will give the teacher a statement of the particular defects which exist and this information will provide a basis for prescribing corrective instruction. As typical of this procedure we quote the following:[1]

A detailed analysis of the faults which appear in the child's writing and of the adjustments which are necessary to correct them has been worked out by Mr. C. W. Reavis, Principal of the Laclede School, St. Louis, Missouri, on the basis of his experience in supervision, and is here presented with his permission.

ANALYSIS OF DEFECTS IN WRITING AND THEIR CAUSES, IN USE BY PRINCIPAL REAVIS

Defect	*Cause*
Too much slant	1. Writing arm too near body. 2. Thumb too stiff. 3. Point of nib too far from fingers. 4. Paper in wrong position. 5. Stroke in wrong direction.
Writing too straight	1. Arm too far from body. 2. Fingers too near nib. 3. Index finger alone guiding pen. 4. Incorrect position of paper.
Writing too heavy	1. Index finger pressing too heavily. 2. Using wrong pen. 3. Penholder of too small diameter.
Writing too light	1. Pen held too obliquely or too straight. 2. Eyelet of pen turned to side. 3. Penholder of too large diameter.
Writing too angular	1. Thumb too stiff. 2. Penholder too lightly held. 3. Movement too slow.

[1] Freeman, F. N., *The Teaching of Handwriting* (Houghton Mifflin Company), pp. 71–72.

Writing too irregular	1. Lack of freedom of movement. 2. Movements of hand too slow. 3. Pen gripping. 4. Incorrect or uncomfortable position.
Spacing too wide	1. Pen progresses too fast to right. 2. Too much lateral movement.

QUESTIONS AND TOPICS FOR STUDY

1. A teacher may judge the handwriting of his class by watching the pupils while they write or by examining the specimens which they have written. Which is the better method if the purpose is to make comparisons of classes? Which is better for discovering the handwriting defects of individual pupils? What factors would you keep in mind in watching children while they write? What factors in the other method?
2. Ask a class to write the three sentences from Lincoln's *Gettysburg Address.* Direct them to start together and write as *rapidly* as they can for one minute. At the end of one minute stop them and direct them to record the number of *letters* they have written. Then ask them to begin again and write for one minute writing as *well* as they can. If you wish to eliminate practice effects, repeat the experiment, again reversing the order of the directions. Note the difference in the rates due to the nature of the directions.
3. Select ten or preferably one hundred specimens of handwriting and rate them every day for several days by means of the scale you have. Keep the record of your day's rating, but do not use them to help you in making future ratings. After several ratings note the consistency of your ratings.
4. Use the Gray Score Card (or Freeman Scale) in scoring the poorer specimens of handwriting. Prescribe the drills you would use in correcting these defects. Compare this with the recommendations of other teachers or students. Try your prescription on the pupils concerned if possible.
5. For what purpose would you use the dictation exercises?
6. Select a defect of letter formation frequently found in a pupil's handwriting. Direct the pupil's attention to this defect and challenge him to correct it. Direct that a record be taken as follows: If the defect were found in letter "a" instruct the pupil to count the number of such errors to be found in fifty consecutive "a's" as they occur in his handwriting written prior to the time you pointed out the defect. After a period of practice, direct the pupil to make another counting from his handwriting written at some period other than the writing period.

CHAPTER IX

THE MEASUREMENT OF ABILITY IN LANGUAGE AND GRAMMAR

The measurement of ability to write compositions. The plan for measuring the ability of pupils to write compositions is very similar to that used for handwriting. Composition scales have been devised which consist of a number of compositions arranged in order of merit, and a pupil's composition is measured by "matching" it with the composition of the scale which most nearly equals it in merit. As in the case of handwriting, care must be exercised in securing compositions from pupils. The first draft of a composition is frequently inferior to the form obtained when it has been rewritten. Also there will probably be a difference between compositions written as a class exercise and compositions prepared as home work.

The Willing Composition Scale for measuring compositions written as a class exercise. Willing[1] has devised a scale which consists of compositions written as a class exercise. The topic was "An Exciting Experience." Several particularly exciting experiences were suggested by the teacher and the pupils were allowed twenty minutes for writing. The compositions were rated both for form (errors in spelling, punctuation, capitalization, and grammar) and for "story value." Those chosen for the scale increase gradually in both form and "story value." The scale is reproduced here so that teachers may understand better this type of measuring instrument in the field of composition.

[1] Willing, M. H., "The Measurement of Written Composition in Grades IV to VIII"; *English Journal* (March, 1918), vol. 7, p. 193.

WILLING SCALE FOR MEASURING WRITTEN COMPOSITION

(The values: 90, 80, 70, 60, 50, 40, 30, and 20 given the respective samples are arbitrary and merely for practical convenience. 20 means 15 to 24.9, 30 means 25 to 34.9, etc.)

20

Deron the summer I got kicked and sprain my arm. And I was in bed of wheeks And it happing up to Washtion Park I was going to catch some fish. And I was so happy when I got the banged of I will nevery try that stunt againg

---

Number of mistakes in spelling, punctuation, and syntax per hundred words, 30.

30

The other day when I was rideing on our horse the engion was comeing and he got frightened so he through me down and I broke my hand.

And the next thing I done was I went to the doctor and he put some bandage on it and told me to come the next day so I came the next day and he toke the bandage off and he look at it and then it was better.

Number of mistakes in spelling, punctuation, and syntax per hundred words, 23.

40

My antie had her barn trown down last week and had all her chickens killed from the storm. Whitch happened at twelve oclock at night. She had 30 chickens and one horse the horse was saved he ran over to our house and claped on the dor whit his feet. When we saw him my father took him in the barn where he slepped the night with our horse. When our antie told us about the accident we were very sorry the next night all my anties things were frozen. The storm blew terrible the next morning and I could not go to school so I had to stay home the whole week.

Number of mistakes in spelling, punctuation, and syntax per hundred words, 17.

50

One time mother and father were going to take sister and I for a long ride thanksgiving, We had to go 60 miles to get there, When sister and I herd about it we were very glad. It was a very cold trip. We four all went in a one seated automobile. Dady drove and mother held me and sister sat on the top the top was down. Mother could not hold sister for she was two heavy. When we got there they had a hot fire ready for us and a goose dinner. We were there over night. In the morning it was hot out. This was on a farm. Sister and I got to go horse-back riding. It was lots of funs. They had children. The children were very nice. Our trip home was very cold. When we got home it had snod.

Number of mistakes in spelling, punctuation, and syntax per hundred words, 14.

60

One time when mother, some girl friends and myself were staying up in the mountains. An awful storm came up. At the we were way up the mountain. The lightning flashed and the thunder roared. We were very frightened for the cabin we were staying at was at the foot of the mountain. We did n't have our coats with us for it was very warm when we started. There were a few pine trees near us so we ran under them. They did n't do much good for the rain came down in torrents. The rain came down so hard that it uprooted one of the trees. Finely it began to slack a little, So we thought we would try and go back. About half way down the mountain was a little hut. We started and when got about half way down it began to rain all the harder. We did n't know what to do for this time there was n't any trees to get under. We decided to go on for the nearest shelter was the hut. Finely we got there cold and wet to the skin.

Number of mistakes in spelling, punctuation, and syntax per hundred words, 11.

70

When I was in Michegan I had an exciting thing happen or rather saw it, it was when the big steamship plying between Chi-

cago and Muskegon was sunk about 7 o'clock in the evening. It caught on fire with a load of cattle and products from the market on board, one of the lifeboats carrying some of the people who were on board landed at our pier. The "Whaleback" steamer which goes between Chicago and Muskegon was two hours later in coming than the freighter and was stopped to clear up the wreckage. all of the cattle and products and an immense cargo of coal were lost, but there were only two people lost. the ship tried hard to get to port with her cargoe but, could not reach it. The next morning we found planks, and parts of the wreck on the beach. Our cottage was at the top of a cliff and it was just one hundred feet to the lake from our cottage, we had a beautiful view, and the sight of the fire on the horizon was a beautiful sight (though it was pitiful).

Number of mistakes in spelling, punctuation, and syntax per hundred words, 8.

80

Near our ranch in Fort Logan there was a chicken ranch. One day my sister and I went up to the chicken ranch on our horses. Coming back there was a road leading from our house to the main road and along this road were half rotted stumps. On every one of these stumps what do you think we saw. We saw snakes! snakes! snakes! I suppose these snakes were shedding their skins, they were of every color, shape, and size. But when sister and I saw these snakes we whipped our horses into a gallop and away we went just as hard as we could go. When we got to the house we went in and mamma could n't get us out of the house that day. I was so scared that I believe I dreamed about snakes for a month.

Number of mistakes in spelling, punctuation, and syntax per hundred words, 5.

90

The most exciting experience of my life happened when I was but five years of age. I was riding my tricycle on the top of our high terrace. Beside the curbing below, stood a vegetable wagon and a horse. Suddenly I got too near the top of the terrace. The front wheel of my tricycle slipped over and down I went, licety-split, under the horse standing by the curbing. I had quite a high

tricycle and the handlebars scraped the horse's stomach, making him kick and plung in a very alarming manner. I was directly under him during this, but finally rolled over out of his way and scrambled up. I looked at my hands! Most of the first finger and part of the thumb of my left hand were missing. The horse had stepped on them. I had endured no sensation of pain before this, but now my mangled hand began to hurt terribly. I was hurried to the hospital and operated on, and now you would hardly notice one of my fingers is missing. I certainly have good cause to congratulate myself on my good fortune in escaping with as little injury to myself as I did, for I might have been terribly mangled in my head or body.

Number of mistakes in spelling, punctuation, and syntax per hundred words, 0.

Directions for using Willing's Scale for Written Composition

In using the Composition Scale, these directions should be followed carefully because the compositions were written by school children who followed these same directions.

1. The teacher should make certain that all pupils are provided with good pen points and ink, or well-sharpened pencils if pencils are to be used. Have distributed to each pupil two sheets of theme paper (approximately 8½ by 11). It is best to use theme paper which has printed at the top the suggested list of topics. If this kind of paper is not used, the teacher must write the following list of topics on the blackboard:

An exciting experience.
A storm.
An accident.
An errand at night.
A wonderful story.
An unexpected meeting.
In the woods.
In the mountains.
On the ice.
On the water.
A runaway.

2. The teacher should then say to the pupils: "I want you to write me a story. It is to be a story about some exciting experience that you have had, about something or other very interesting that has happened to you. If nothing of the sort has ever happened to you, then tell me of an exciting experience some one you know has had. You may even make up a story of this kind, if you have to, though I believe you will do better, on the whole, with a real one. I am going to give you about twenty minutes in which to write. You are to write on both sides of the paper, to do all the work yourselves, and to ask no questions at all after you begin. You may make whatever corrections you wish between the lines. There will be no time to rewrite your story.

"The general subject together with some suggestions is printed at the top of the paper on which you are to write. (I have written the general subject on the blackboard, together with some suggestions.) You do not have to write on any of these topics unless you want to; they are merely to help out in case you cannot think of an exciting experience yourself. You may begin now as soon as you wish."

3. Allow opportunity for asking questions and make an effort to put the children at ease. Allow full twenty minutes for the actual writing. At the end of this time say to the pupils:

"You are to have four or five minutes in which to finish your stories; make corrections and count the number of words written. Write this number at the end of your story, write also your name, age, and grade."

At the end of five minutes collect the papers.

It is important that the pupils be not allowed to correct their compositions, except such corrections as they may make during this period of four or five minutes. The teacher must remember that it is this type of composition which was used in making the scale and establishing the standards.

4. In rating the compositions by means of the scale, two qualities are recognized: (1) "story value" and (2) "form value." The composition should be rated for "story value" first.

Rating for "Story Value." Read the compositions, neglecting all errors of grammar, punctuation, capitalization, and spelling, and keeping in mind only the value of the story which the pupil is telling. As the compositions are read, sort them into piles, placing in one pile those which most nearly resemble in "story

value" composition 20 of the scale; in another pile those which most nearly resemble composition 30; in another pile those which most nearly resemble composition 40; and so on for the other compositions of the scale.

After this is done, compare the compositions in each pile with each other, in order to make sure that the rating has been done correctly. Make any adjustments which you think should be made. Mark each composition with the value of the scale composition which it most nearly resembles. In case you believe that the true "story value" of the pupil's composition lies between that of two of the scale compositions, the interpolated marks 25, 35, etc., may be used.

Rating for "Form Value." After the compositions have been rated for "story value," carefully mark all errors in grammar, punctuation, capitalization, and spelling. Count these errors and multiply the total by 100. Divide this number by the number of words in the composition. This quotient is the number of errors per hundred words.

The quotient found, as directed above, and the "story value" of the composition constitute the pupil's score. These scores are valuable to the teacher. They show the standing of each pupil in two respects. They tell the teacher whether the pupil needs to give attention to the "form" of his writing (grammar, punctuation, capitalization, and spelling) or to the "story value," or to both.

Recording the scores. For recording the scores the record sheet shown in Fig. 38 is used. Sort the compositions for a class into piles according to their "story value." (By a class we mean the pupils who belong to the same grade and who recite together. If a teacher has a class composed of pupils belonging to two grades — say some belonging to 5 A and some belonging to 6 B — it will be necessary to make two tabulations.)

If interpolated values have been used, they should be grouped according to the explanation of the scale value which is given at the top of the scale.

Take the compositions whose "story value" is 20. These are to be listed in the first column of the table in the space which corresponds to their "form value." For example, in the first space of this column record the number of these compositions whose "form value" is between 0 and 2.9; in the second space record the number of compositions whose form value is between 3 and

Class Record Sheet

City ....School..........................Grade............
Teacher ....Date.......................191....

Errors per Hundred Words	Story value								Distribution for Errors
	20	30	40	50	60	70	80	90	
0 to 2.9	....	....	....	....	....	....	....	....	....
3 to 5.9	....	....	....	....	....	....	....	....	....
6 to 8.9	....	....	....	....	....	....	....	....	....
9 to 11.9	....	....	....	....	....	....	....	....	....
12 to 14.9	....	....	....	....	....	....	....	....	....
15 to 17.9	....	....	....	....	....	....	....	....	....
18 to 20.9	....	....	....	....	....	....	....	....	....
21 to 23.9	....	....	....	....	....	....	....	....	....
24 to 26.9	....	....	....	....	....	....	....	....	....
27 to 29.9	....	....	....	....	....	....	....	....	....
Above 30	....	....	....	....	....	....	....	....	....
Distribution for "story value"	....	....	....	....	....	....	....	....	....

Class Medians. Form value............ Story value............

FIG. 38. SHOWING CLASS RECORD SHEET FOR USE WITH WILLING'S COMPOSITION SCALE

5.9; in the third space record the number of compositions whose "form value" is between 6 and 8.9, etc. After the compositions in each pile have been recorded in this way, the number of compositions recorded on each line should be counted and the total entered in the total column. The same should be done for the compositions entered in each column.

Finding the class scores. The median score for form value may be found by arranging the compositions in order of the form scores and taking the score of the middle composition. In case there is an even number of papers, the average of the scores on the two middle ones should be taken. The median score for "story value" may be found in the same way. The median scores may also be calculated from the distributions by following the directions given on page 103.

Tentative standards. Tentative standards for Willing's Composition Scale are given in Table XXIII. It will be noticed that the median scores for Denver are conspicuously below those for five Kansas cities. This may be due to the fact that reports have been received from only a few cities.

TABLE XXIII. MEDIAN SCORES FOR WILLING'S COMPOSITION SCALE

Grade	*Denver*		*Five Kansas cities*	
	Story value	*Form value*	*Story value*	*Form value*
IV	32	22	44	12
V	48	16	58	10
VI	50	14	75	5
VII	60	11	77	5
VIII	63	10	82	6

Other scales for measuring written composition. A scale called the *Nassau County Supplement* has been devised by Trabue. It consists of nine compositions, seven of which

were written by elementary-school pupils on the topic, "What I should like to do next Saturday." It is designed to measure only "story value" of compositions. Copies of this scale may be obtained from the Bureau of Publications, Teachers College, Columbia University, New York City.

The Hillegas Scale consists of ten compositions ranging from an artificial production whose scale value is zero to the tenth composition whose scale value is 9.3. Three of the ten compositions are artificial productions, five were written by high-school pupils, and the remaining two by college freshmen. No two were written on the same topic and they vary greatly in length and type. In the *Thorndike Extension of the Hillegas Scale*, only a few of the compositions of the original scale have been used and several compositions are given for each degree of merit in the middle of the scale. Twenty-nine compositions represent fifteen degrees of merit within approximately the same range as the original scale. This makes a more finely divided scale than the original one. Copies may be obtained from the Bureau of Publications, Teachers College, Columbia University, New York City.

The Harvard-Newton Composition Scale consists of four separate scales, one for each form of discourse; argumentation, description, exposition, and narration. Each of the scales consists of six compositions written by eighth-grade pupils and arranged in order of merit as determined by the marks assigned by teachers rating them as eighth-grade compositions. For each composition there is given a statement of the most significant merits and defects. Copies of the scale may be secured from the Harvard University Press, Cambridge, Massachusetts.

The compositions used by Breed and Frostic[1] in deriving

[1] Breed, F. S., and Frostic, F. W., "A Scale for Measuring the General Merit of English Composition"; in *Elementary School Journal*, vol. 17, pp. 307–25.

their scale were written by sixth-grade pupils under uniform conditions. A part of the story called "The Picnic" was read to the class and they were given twenty minutes to complete it. The method of selecting compositions for the scale and determining scale values was similar to that employed by Hillegas.

The measurement of ability in English Grammar. Charters's Diagnostic Test in Language and Grammar for Pronouns. Charters collected more than twenty-five thousand errors that pupils make in using pronouns in their oral language. These were classified under forty heads; that is, there were only forty different kinds of errors in the use of pronouns in the total twenty-five thousand. The language part of the test consists of forty sentences. The pupils are required to write the correct form. This test is designed to be used in grades three to eight. In the grammar part of the test, which consists of the same forty sentences, they are required to give the reason for making the correction. The form of this test is illustrated by a few of the exercises given on the next page. It is recommended for use in the seventh and eighth grades. This test measures two abilities: (1) The ability to use correct forms of pronouns. The measure of this ability is his "language score" and is the number of the language exercises done correctly. (2) The ability to give the grammatical rule which tells which form is correct. The measure of this ability is his "grammar score" and is the number of the grammar exercises done correctly.

Recording the scores. For this purpose a class record sheet with detailed directions is furnished with the tests.

Recording scores for purpose of diagnosis. In order to obtain a diagnosis of the abilities of the pupils of a class, the form of tabulation which is partly shown in Fig. 38 is helpful. It gives in a compact form the record of each pupil

8. Who do you want? ....

....

16. They made baskets and filled it with holly...

....

28. Was that him? ....

....

8. ....

....

16. ....

....

28. ....

....

SAMPLE EXERCISES FROM CHARTERS'S DIAGNOSTIC TEST IN LANGUAGE AND GRAMMAR FOR PRONOUNS

Name of pupil	*Number of Exercises*																		
	2		3		4		5			37		38		39		40		*Total*	
	L	*G*	*L*	*G*	*L*	*G*	*L*	*G*		*L*	*G*	*L*	*G*	*L*	*G*	*L*	*G*	*L*	*G*
....	...	...	...	...	...	...	...	...	......	...	...	...	...	...	...	...	...	...	...
....	...	...	...	...	...	...	...	...	......	...	...	...	...	...	...	...	...	...	...
....	...	...	...	...	...	...	...	...	......	...	...	...	...	...	...	...	...	...	...
....	...	...	...	...	...	...	...	...	......	...	...	...	...	...	...	...	...	...	...
....	...	...	...	...	...	...	...	...	......	...	...	...	...	...	...	...	...	...	...
....	...	...	...	...	...	...	...	...	......	...	...	...	...	...	...	...	...	...	...
....	...	...	...	...	...	...	...	...	......	...	...	...	...	...	...	...	...	...	...
....	...	...	...	...	...	...	...	...	......	...	...	...	...	...	...	...	...	...	...
....	...	...	...	...	...	...	...	...	......	...	...	...	...	...	...	...	...	...	...
....	...	...	...	...	...	...	...	...	......	...	...	...	...	...	...	...	...	...	...
....	...	...	...	...	...	...	...	...	......	...	...	...	...	...	...	...	...	...	...
....	...	...	...	...	...	...	...	...	......	...	...	...	...	...	...	...	...	...	...
....	...	...	...	...	...	...	...	...	......	...	...	...	...	...	...	...	...	...	...
Total.......	...	...	...	...	...	...	...	...	......	...	...	...	...	...	...	...	...	...	...
Per cent correct....	...	...	...	...	...	...	...	...	......	...	...	...	...	...	...	...	...	...	.
Standard...	...	...	...	...	...	...	...	...	......	...	...	...	...	...	...	...	...	...	.

FIG. 39. RECORD SHEET FOR DIAGNOSIS

Charters's Diagnostic Test in Language and Grammar. Exercises 1 and 29 are omitted because they are correct sentences.

on each exercise. With this tabulation before him the teacher can determine (1) what errors should be given more emphasis and (2) what pupils are lacking in ability. Since the test includes all the pronoun errors, the teacher may be sure that his pupils have been tested completely in this field.

Standards. No standards are yet available for this test, but those desiring to use it may obtain the standards from the Bureau of Educational Research, University of Illinois, Urbana, Illinois, as soon as they have been determined.

Starch's Punctuation Scale. Starch has devised a punctuation scale, which consists of a number of sentences which the pupil is to punctuate correctly. The sentences are grouped in exercises of gradually increasing difficulty of punctuation. The nature of the scale may be illustrated by the following extracts. The pupil's score is the value of the highest step which he does seventy-five per cent correct.

Step 6

1. We visited New York the largest city in America.
2. Everything being ready the guard blew his horn.
3. There were blue green and red flags.
4. If you come bring my book.

Step 7

1. I told him but he would not listen.
2. Concerning the election there is one fact of much importance.
3. The guests having departed we closed the door.
4. The train moved swiftly but Turner arrived too late.

Step 10

1. A tall square building is located on State Street.
2. Washington Irving whose personality was genial and charming became very popular in England.
3. You see John how I stand.
4. On the path leading to the cellar steps were heard.

Step 13

1. I saw no reason for moving therefore I stayed still.
2. There are three causes poverty, injustice and indolence.

Step 16

1. As in warfare a band of men though strong and brave individually is collectively weak if it is not well organized so a speech a report an editorial an essay any composition though its parts may be forcible or clever is weak as a whole if it is not well organized.

Standards. The following are tentative standards of attainment for the ends of the respective school years:

Grade	*Score*
Seventh	8.0
Eighth	8.3

No diagnosis obtained. Starch's Punctuation Scale does not yield a diagnosis because he did not analyze the field of punctuation to determine the types of sentences requiring punctuation. In this respect, as well as in others, it differs from Charters's Diagnostic Test in Language and Grammar described above.

Measuring accuracy in copying. Copying is a phase of school work which receives little explicit attention. This is probably due to the assumption that pupils are able to copy accurately because it appears to be such a simple activity. Copying bears a relation to written expression and to other school subjects as well. Themes are usually copied before being submitted to the teacher. In solving problems in arithmetic the quantities are copied from the text. In gathering information from references copying occurs.

The Boston test. The following test of pupils' ability to copy printed matter was prepared by a group of Boston[1] teachers:

[1] *Determining a Standard in Accurate Copying.* (Boston Public Schools, English, School Document no. 2, 1916.)

DIRECTIONS FOR GIVING AND SCORING THE TEST

1. Read to the pupils the directions which are printed at the head of the selection they are to copy, but give them no further help. For example, do not specify possible errors which may be made.
2. Pupils ought not to see the selection until they are ready to copy it. Hence it should be placed on the desk face down until the signal is given to begin work.
3. Every error should be checked distinctly.
4. The errors which were to be noted were as follows: In spelling, capitalization, punctuation, undotted "i's," uncrossed "t's"; in omitting words, in adding words, in wrong words used, and in misplaced words.

Directions to Pupils

Copy in ink as much of the following selection as you can copy accurately in fifteen minutes without hurrying. Accuracy is more important than speed:

Lieutenant Ouless

In this story a young British lieutenant, in a moment of extreme irritation, strikes a private soldier. The act is one that calls for dismissal from the Queen's service. What is the officer to do? He cannot send money to the soldier — who happens to be the redoubtable Ortheris himself — nor can he apologize to him in private. Neither can he let matters drift. Ortheris, too, has his own code of pride and honor; he too is a "servant of the Queen"; but how is the insult to be atoned for? The way out of this apparently hopeless muddle is a beautifully simple one, after all. The lieutenant invites Ortheris to go shooting with him, and when they are alone, asks him "to take off his coat." "Thank you, sir!" says Ortheris. The two men fight until Ortheris owns that he is beaten. Then the lieutenant apologizes for the original blow, and the officer and private walk back to camp devoted friends. That fight is the moral salvation of Lieutenant Ouless.[1]

Kinds of errors made. This test was given to 4494 first-year pupils in the Boston High Schools in November, 1914,

[1] Bliss Perry, *A Study of Prose Fiction.*

and therefore may be considered to measure the ability of pupils completing the eighth grade. The results are both interesting and significant. The following is quoted from the Bulletin mentioned above:

The errors noted consisted of nine different kinds, and the number of each kind made in this test by 4494 pupils is shown by the following tabulation:

Spelling	5,829
Capitalization	644
Omitted words	4,077
Added words	606
Wrong words used	840
Misplaced words	105
Punctuation	5,876
Undotted "i's"	8,794
Uncrossed "t's"	606
Total	27,377
Average errors per pupil	5.54

Misspelled words. The test consisted of 170 words, 105 of them different words. It is a notable fact that every word was misspelled by somebody. It is also interesting that 92.2 per cent of the words in the test are found in Jones's *Concrete Investigation of the Material of English Spelling.*[1] In spite of the fact that these are words commonly used by children in their writing, 11.8 per cent of them were misspelled more than 100 times. This does not mean that 11.8 per cent of the children missed these words, because one pupil might have missed the same word more than once.

It is impossible to make any statement in regard to the average because many of the words occur in the selection more than once, and if misspelled by the same person each time it occurs it is counted more than one error. Some children spelled a word incorrectly in one place and correctly in another. One boy spelled "lieutenant" wrong four out of five times, and spelled it a different way each time. Then, not all the children finished the entire selection, and no record was kept of the exact number of words each

[1] Published by the University of South Dakota.

wrote. However, 4494 pupils taking the test made 6820 errors in spelling alone, the number of errors for each word varying from 1 to 1045.

Undotted "i's" and uncrossed "t's." The errors made by leaving the "i's" undotted and the "t's" uncrossed comprise about one third of the entire number of errors and are largely important because of their value to legibility, as pointed out by Ayres. In connection with these errors, it is very noticeable that most of them were confined to comparatively few pupils. If a child showed a tendency to dot his "i's" and cross his "t's" in the first few lines, the chances were that that individual would have but few errors. On the other hand, if the child made many errors in the first part of the paper, there were many throughout the copying. One boy went through the entire paper without dotting an "i." Many others dotted only a small part of them.

The same test was given in Kansas City, Missouri, to the pupils in the seventh grade and in the first year of the high school. (Kansas City has only seven grades below the high school.) The average errors per pupil were 8.04 in the seventh grade, and 6.83 in the first year of high school.

Remedying the situation revealed. When a teacher learns the specific language weaknesses of his pupils, he is then in position to apply more intelligently his stock of methods and devices of instruction. In language, as in the case of the other subjects, the teacher must instruct individual pupils who are grouped together rather than groups of pupils. Furthermore, each pupil should receive the instruction which he needs to correct his language errors.

If pupils are weak in a language ability, such as punctuation, the laws of habit formation apply. After being sure that he understands the function of the punctuation marks, a pupil must have practice in punctuating his own writing. This probably is not sufficient. Exercises for practice can be constructed by taking appropriate material and reproducing it without the punctuation marks.

Until a teacher recognizes definite and specific ends to be attained, there is certain to be a large degree of dissipation of his efforts. Perhaps one reason why language instruction so often does not produce satisfactory results is that it is not directed toward the engendering of definite abilities. That our present standards of language are chaotic is indicated in the report of a recent investigation.[1]

Present standards for composition indefinite. Six compositions were typewritten without any identifying marks. They were "graded" on the scale of 100 per cent by twenty-four eighth-grade teachers who were asked to follow certain typewritten directions. The six compositions were then "completely corrected so far as mechanical or measurable errors were concerned." The corrected compositions were graded by the same teachers according to the same directions.

If the "mechanical errors" of the compositions were significant factors in determining the first set of marks, the second set of marks should be conspicuously higher. However, this was not the case. For two of the compositions the average "grade" was less after the "mechanical errors" had been corrected. The individual marks show that some teachers consider form important, and that others tend to disregard it in marking a composition.

Keeping a record of pupils' errors. In teaching spelling, teachers have kept a record of pupils' errors and have emphasized these words in their teaching. In our consideration of spelling it was urged that teachers first ascertain what words their pupils were unable to spell correctly. This plan may be adapted to the teaching of other aspects of language. The teacher should ascertain the pupils' grammatical errors, and then equip them with the rules of grammar which are

[1] Brownell, Baker, "A Test of the Ballou Scale of English Composition"; in *School and Society*, vol. 4, pp. 938–42.

needed to correct them. This has been done on a large scale in St. Louis and Kansas City, Missouri.[1]

The point of view in locating errors and applying correctives is most important. Perhaps the scales and tests described in this chapter will have fulfilled their most important function if they cause teachers to analyze and define "language ability" in more specific terms. It is believed that their use will tend to produce this result, especially such a test as Charters's Diagnostic Test in Language and Grammar for Pronouns which is based upon an analysis of that field. Analysis of "language ability" and specific definition of the elements are greatly needed. Upon the accomplishment of these two things depends the construction of more valuable measuring instruments in the language field and the scientific determination of methods and devices of instruction.

QUESTIONS AND TOPICS FOR STUDY

1. Give the copying test to your pupils following the directions carefully. Do the results agree with your estimate of the ability of your pupils to copy?
2. Keep accurate lists of the language errors of your pupils both oral and written. What are the rules which are necessary to correct these errors? Are they the rules upon which you are placing the most emphasis in your teaching?
3. Do you have definite objective standards of attainment in English composition? Can you use the scales described in this chapter to establish such standards?
4. Do you think pupils would be helped by having definite objective standards of attainment established for them?
5. Secure a copy of Willing's Composition Scale and post it in the classroom. Have pupils measure their compositions with it.
6. Why is Charters's Diagnostic Test in Language and Grammar more helpful to the teacher than Starch's Punctuation Scale?
7. What do you think of Charters's method of determining what exercises to use? Is it a good method? Why?

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[1] See report by W. W. Charters in the *Sixteenth Yearbook of the National Society for the Study of Education*, part I.

CHAPTER X

THE MEASUREMENT OF ABILITY IN GEOGRAPHY AND HISTORY

GEOGRAPHY and history are different from the school subjects treated in the preceding chapters. Subjects such as reading, the operations of arithmetic, spelling, and the like are sometimes called "tool subjects" to distinguish them from such subjects as geography and history which are called "content subjects." Silent reading is a tool which a pupil uses in studying geography and history. The operations of arithmetic are tools which are used in solving problems.

Several tests have been devised for both geography and history, and, although they are open to criticism, they are more effective as a measuring instrument than tests or examinations prepared by the teacher. The questions have been very carefully selected, have been evaluated, and the tests have been standardized. In both geography and history there are a very large number of items of information. Some of these are important, while others are unimportant. Authorities agree on the importance of some facts; on others they disagree. Hence, the selection of the questions is very important. On page 10 we found that questions were not equally difficult, and hence it is important to have the amount of credit to be given for each question scientifically determined. Finally, pupils' scores cannot be interpreted without standards.

The criticism is frequently made, that while it is possible to measure "what a pupil remembers," it is not possible to measure his ability to answer "thought questions." This

statement is not true. It is possible to measure the ability of pupils to think. However, it is very significant that investigation has shown that there is a very definite connection between a pupil's ability to remember and his ability to think. One investigator [1] in history showed that there was a very close agreement between a pupil's score on a memory test and his score on a thought test. This result is just what we should expect when we recall that reasoning involves the use of facts and a person cannot reason effectively unless he has command of the necessary facts. The application of this relation between ability to remember and ability to think is that in using a memory test, we are also indirectly measuring the ability of pupils to think in the same field. For the most part tests in geography and history have been devised so recently that we do not have proof of their value as we do in reading and arithmetic. However, certain ones of the available tests give promise of being helpful to the teacher. In this chapter we will describe two tests in geography and one test in American history.

I. Geography

1. Courtis's Standard Tests in Geography for States and important cities of the United States.[2] This test is explicitly designed to cover only two topics of geography, but all teachers will probably agree that they are important ones. The plan of the test is to provide each pupil with an outline map of the United States showing the boundaries of the several States. Each State is given a number. The first part of the test consists of answering for each State the question, "On the map above what is the number of ....?" In the second part of the test the pupil is

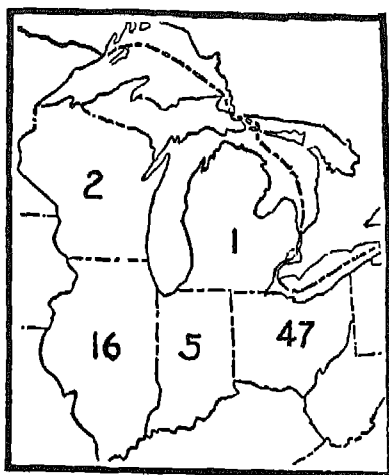
[1] Buckingham, B. R., "Correlation between Ability to Think and Ability to Remember, with Special Reference to United States History"; in *School and Society* (April 14, 1917), vol. 5, p. 443.

[2] Prepared in coöperation with B. A. Barnes, Supervisor of Geography, Detroit Public Schools.

asked to give the number of the State in which certain cities are located. The preliminary test which is given, so that the pupil may understand just what he is to do, is reproduced in Fig. 40, to illustrate this type of test.

INSTRUCTIONS

Write after each state the number printed in that state, on the map at the right. For instance: Write 1 after Michigan. What number should be written after Ohio?

In the same way, after each city write the number of the state in which that city is located. Write 1 after Detroit. What should be written after Chicago?

STATE

Questions	Number	
1. Michigan?.......	....	....
2. Ohio?	....	....
3. Indiana?	....	....
4. Illinois?.........	....	....
5. Wisconsin?......	....	..

CITY

Questions	Number	
1. Detroit?.........	....	....
2. Chicago?	....	....
3. Cleveland?	....	....
4. Indianapolis?...	....	....
5. Madison?..... ..	....	....

FIG. 40. ILLUSTRATING COURTIS'S STANDARD TEST IN GEOGRAPHY FOR STATES AND IMPORTANT CITIES OF THE UNITED STATES

Marking the test papers and recording the scores. Detailed directions for marking the test papers and for recording the scores are furnished with the test and hence need not be given here.

2. **Hahn-Lackey Geography Scale.** A different type of test has been devised by H. H. Hahn and E. H. Lackey. This scale consists of questions which were very carefully selected. The plan of selection is described as follows :[1]

Since texts will be used by a large majority of teachers for years to come, our primary purpose was to construct a scale for the testing of the teaching of geography from *text*-books. But when we realized that not one but a number of texts are being taught, we had to modify our plan. Our first modification consisted of limiting our questions to the phases of geography treated in common by six modern texts. Then we found that some of these phases were treated more fully by some authors than they were by others. A second modification of our plan was, therefore, necessary; namely, to select the common subject-matter, or, in other words, the esentials of subject-matter in each phase. In the selection of the essentials of subject-matter, the common subject-matter in these texts was largely our guide, but we also checked our exercises by principles and minimum essentials as they have been worked out by makers of geography curricula. (See 1914 and 1916 *Yearbook* [of the National Society for the Study of Education].) Over six hundred questions and exercises were selected by three teachers, covering this common subject-matter. These exercises were then examined by the authors of the scale, first, with reference to repetitions, and duplications were eliminated. They were next examined for language difficulty. The wording of many of the exercises was changed, some of them were actually tried out on children, and in many instances technical expressions which would convey exact meaning to mature students of geography were eliminated and the ordinary language of children substituted. This is particularly true of the exercises in the lower reaches of the scale. The exercises intended for the upper reaches of the scale were not freed from technical expressions the meaning of which pupils are

[1] From an unpublished account of the derivation of the scale by the authors.

expected to know as evidence of geography ability. Thus we find such expressions in the scale as "the Fall Line," "climate," "continent," "natural wonders," "natural geographic barriers," "agencies," "cyclonic storms," and many others equally as technical. The exercises were examined, in the third place, as to their scope, as suggested before. Nothing was included beyond the essentials of geography. Finally, the list of exercises was revised so that it contained about an equal number of memory and thought questions.

These questions were classified according to difficulty by giving them to 1696 pupils in twelve schools in two States. A section of the scale is reproduced in Fig. 41. The numbers at the top of the columns represent the per cent of correct answers which were given by the 1696 pupils. These per cents are tentative standards.

Using the scale. This geography scale is a classified list of questions from which the teacher can select questions for a test. Since the questions in any column are equally difficult, it is best to take the questions for a test from one column. These may be given in the usual way by writing them on the board. It is better if each pupil is provided with a mimeographed copy with space left for writing in the answers. The teacher should not explain the meaning of any words used in the questions because the results will then not be comparable with the standards. Ten questions will make a test of convenient length and probably is the best number to use.

Scoring the papers. When ten questions are used and all have been chosen from the same column, each one may be considered to have a value of 10 credits. This will make the total number of credits 100. For scoring the papers the authors have prepared a score card. The portion of it which applies to the section of the scale reproduced in Fig. 41, is given below. These directions must be followed if the resulting scores are compared with the standards. The score of a

pupil is the sum of the credits which he earns on the list of questions. The class score is the average of the scores of the members of the class.

What to accept and what to reject in scoring answers. Many of the exercises in the Hahn-Lackey Geography Scale admit of only one answer; but the scale contains exercises to which the answers may vary. In order that the scoring of the answers by teachers of different localities may be uniform and the scores be comparable with those of the scale, the authors have prepared a list of typical answers they accepted and typical answers they rejected in making the scale. In this list the answers to the exercises are given in the order in which they occur in the position of the scale reproduced in Fig. 41.

"F" means full credit; "P" means part credit; "N" means no credit.

42. Different kinds of meat was credited as only one kind of food.

1. F. "Brazil"; "South America"; "Mexico"; "Central America."

103. F. "Rays fall more vertical"; "Farther south"; "Nearer the equator."
N. "Ocean breezes"; "Gulf Stream."

104. F. "Capacity for water"; "Can go a long time without a drink."

18. F. "Let it down in the valleys or sea"; "Leave it on the bank"; "Form Islands"; "Drop it at the mouth"; "Drop it when the current is not swift." (Any answer that indicates that rivers take soil from one place and put it in another place.)

20. F. Any two lines of work; as, "Plants grain and harvests it"; "Raising cattle and farming"; "Raises crops and milks"; "Farming and selling things."
P. One half credit for only one line of work.

98. F. "No food for horses"; "Too cold for horses."

6. F. "Earth" "Land" "Rock" "Stone" "Mountains"; "Sand"; "Plains"; "Plateaus." (Any answer indicating a knowledge of the bed of the ocean.)

Q	R	S	T
42	50	58	66
58	66	73	79
66	73	79	84
79	84	88	92
79	84	88	92

60. Name four fur-bearing animals.

86. Name four large rivers of Europe.

99. What two countries of Asia are noted for tea?

129. Give the capitals of

62. Name the five Great Lakes of North America

73. What are the two largest cities of the United States?

29. Name two ways in which the farmer helps to get food for us.

52. What is the largest city of your state?

64. Where is Alaska and to whom does it belong?

84. Name four large cities of Europe.

92. Give the capitals of

35. Name two kinds of work that men do to keep us warm.

44. Name four things out of which clothing is made

47 Give two ways in which food, clothing, lumber, and coal are brought to

Colorado and Massachusetts.

42. Name two kinds of food that we get from animals.

1. From what country do we get much of our coffee?

12. Which is the largest and which is the smallest, the moon, the sun, or the earth?

71. What country of South America has a climate similar to ours?

103. Why is it warmer in New Orleans than in Chicago?

104. Why are camels such useful animals for traveling in desert places?

9. What is the cause of day and night?

18. What do the rivers do with the soil that they carry?

41. Give two ways in which water gets away when it rains.

3. What is the name of the circle extending around the earth midway between the poles?

98. Give one reason why the people in the far north use reindeer and dogs instead of horses.

37. Why does not the water flow out of swampy places?

46. Why do not the Eskimos build houses like ours?

6. What is under the ocean?

19. Where does the water in a well come from?

23. Name two ways in which winds are useful.

France and Germany.

101. Name two large bodies of water that border on Florida.

45. Name four things you use for food that do not grow where you live.

68. Give one reason why so many of the great cities of the United States are near the sea coast.

72. Which is the coldest and which the warmest part of South America?

us.

48. Give two ways in which goods may be taken across a river.

7. Name four continents.

13. Name two necessary things that we get from the sun.

16. Name four races of men.

124. Give one way in which farming may be done in dry countries.

57. Give two ways in which rivers are useful.

38. Why should roads or streets be higher in the middle than on the sides?

39. How does the ocean help to furnish rain?

20. Where do plants get water?

21. What makes clouds move?

FIG. 41. A SECTION OF THE HAHN-LACKEY GEOGRAPHY SCALE.

19. F. "Out of the ground"; "From veins"; "Springs"; "From little streams in under the ground"; "From moisture in the ground." (Any answer clearly implying underground source.)
23. F. Any two. "Bring rain"; "Turn mills"; "Fresh air"; "Makes temperature equal"; "Makes pressure equal"; "Scatters seeds"; "Causes ocean currents."
68. F. "Good harbors"; "Commerce"; "Importing and exporting goods"; "Trade carried on there."
47. F. Any two. "By railroad"; "Wagon"; "Mail"; "Ships."
48. F. Any two. "Railroad bridge"; "Boat"; "Wagon bridge"; "Fording."
57. F. Any two. "Fish"; "Navigation"; "Sport"; "Water-power"; "Drains the land."
39. F. Any answer indicating a knowledge of the ocean as a source of vapor in the air; as, "Fills the air with vapor"; "Makes air moist."
21. F. "Winds"; "Breezes"; "Air"; "Atmosphere."

Interpreting the scores. Two things must be kept in mind if a satisfactory interpretation of the scores is obtained: (1) The standards given at the head of the columns do not represent the exact per cent of correct answers obtained. For example, 50, the fourth grade standard for column R, represents values from 46.8 to 53.2. Thus, small differences between scores and standards are not significant. (2) The standards are given in terms of a scale of 100 units or a per cent scale. It is also customary to use a per cent scale for reporting "school grades," or at least for defining them. Some per cent, as "60," "70," or "75," is chosen as the "passing mark." A score of 79 on a set of questions chosen from column S of this scale does not mean "79 per cent" as a school mark. This score of 79 is above standard in the fourth and fifth grades. It is just standard in the sixth grade and below standard in the seventh and eighth grades.

When a pupil has a score which is just standard, he is just an average pupil because the standard is an average score.

If five marks, such as A, B, C, D, and E (A being the highest mark), are used, such a pupil would be given a mark of C. If "grades" are reported in per cents and 75 is the passing mark, a score of 79 when the standard is 79 should be translated as about "85 per cent." Scores above and below standard should be interpreted with the standard representing the average.

II. American History

Harlan's Test of Information in American History. The items of information called for by this test are found in practically all American history textbooks, being based on the study by Bagley and Rugg of twenty-three textbooks to determine the content of American history.[1] This insures the questions being well selected. The credit to be given for answering each question has been determined and a score card is furnished with the test so that the marking of test papers may be uniform. The test consists of ten exercises. The first, fourth, and ninth are reproduced to illustrate their nature.

Exercise I

At the right of the page are the names of some men mentioned in American history. Fill in blanks with the names which properly belong there.

	1. America was discovered by..............	
Score......	near the close of the fifteenth century.....	Jefferson
	2. The name of the man who is supposed to	Cornwallis
	have discovered the Pacific Ocean is......	William Penn
	3. The first President of the United States was	Lafayette
	....	Patrick Henry

[1] Bagley, W. C., and Rugg, H. O., *The Content of American History as Taught in the Seventh and Eighth Grades.* (University of Illinois, School of Education, Bulletin no. 16, 1916.)

4. .... is the name of a distinguished Frenchman who aided the colonists in securing their independence.. ..	Columbus Benj. Franklin Washington
5. .... surrendered to the colonial troops at Yorktown............	John Cabot Balboa

EXERCISE IV

Tell the very first thing you would do under each of the following conditions; also what you would do next:

1. If a neighbor were to present to you for your signature a petition to have some man removed from public office, —
   What would you do first? ....
   Would you sign the petition? ....

Score......

2. If a man imprisoned in the county jail for some serious crime should be taken out by a mob with the intention of hanging him, —
   What ought to be done first? ....
   Then what? ....

EXERCISE IX

The following topics represent matters of importance in the history of the United States. State definitely of what significance each has been.

1. Articles of Confederation..............................
   ....

Score ......

2. Mason and Dixon's line...............................
   ....
3. Monroe Doctrine......................................
   ....
4. The Tariff...
   ....

Standards. The total amount of credit allowed for the ten exercises is 100. Over two thousand pupils in the seventh and eighth grades have been tested at the end of the respective years. The median scores are: Seventh grade, 56; eighth grade, 86.

As in the case of geography, these standard scores are the scores which should be made by the average or median (middle) pupils. Consequently, when translating these scores into school marks, a score which is standard should be given the "school grade" which represents the average pupil.

Diagnostic value of the test. The different exercises call for different types of information: dates, names, causes, meanings of historical terms, etc. By tabulating the credits earned on the different exercises in the way given for Charters's Diagnostic Tests in Language and Grammar (Fig. 39), a teacher may learn which phases of history need additional emphasis.

Other tests in geography and American history. Since tests in these two fields have been devised only recently and have not been used sufficiently to determine which ones are most helpful to the teacher we list here other tests. Information concerning them may be obtained by consulting the reference given or by writing to the address.

Geography

1. *The Boston Tests.* The two tests of this series — one on the United States and the other on Europe — consist of well-chosen questions. The relative difficulty of the questions was determined upon the basis of the per cent of correct answers. The tests were devised in an effort to determine (1) the character of achievement in geography, and (2) the possibility of scientific measurement of educational results in geography. This significant comment is made: "The results show how inadequate the customary examination or test in geography is to measure ability in geography." [1]

[1] *Geography; A Report on a Preliminary Attempt to Measure Some Educational Results.* (Boston, Department of Educational Investigation and Measurement, Bulletin no. 5, School Document no. 14, 1915; p. 38.)

2. Buckingham's Geography Test. This test was devised for use in the survey of the Gary and Prevocational Schools of New York City. It consists of two sets of twenty questions which were evaluated upon the basis of the per cent of correct responses.[1]

3. Starch's Geography Tests, Series A. The common elements of five geography texts have been arranged in five parallel tests. The exercises of the tests are in the form of mutilated sentences.[2]

4. Witham's Standard Geography Tests. These are a series of tests arranged to test quickly and easily the pupil's knowledge of certain geographical facts. The facts for the tests on the world are grouped under these heads: (1) geographical divisions, (2) form and motion of the earth, (3) the hemispheres, (4) land and water forms, (5) homes of the races, (6) industries, and (7) largest cities.[3]

5. Branom and Reavis Completion Test for the Measurement of Minimal Geographic Knowledge of Elementary School-Children. This test was very carefully constructed and appears to have a high degree of merit. No standards have been published.[4]

History

1. Buckingham's Tests. These tests were used in the survey of the Gary and Prevocational Schools of New York City. They consist of two sets of questions which have been evaluated on the basis of the per cent of correct answers.

[1] *Seventeenth Annual Report of the City Superintendent of Schools.* (New York City, 1914–15.)

[2] Address Daniel Starch, University of Wisconsin, Madison, Wisconsin.

[3] Witham, E. C., "A Minimum Standard for Measuring Geography"; in *American School Board Journal* (January, 1915), vol. I, pp. 13–14. Address E. C. Witham, Southington, Conn.

[4] *Seventeenth Yearbook of the National Society for the Study of Education,* part I, pp. 27–39. (Public School Publishing Company, Bloomington, Illinois, 1918.)

More recently Buckingham has studied the relation between the ability to remember historical facts and the ability to use them. In this study specially devised tests were used.[1]

2. The Bell and McCollum Test. This test consists of a series of questions which have been very carefully selected because of their importance. The topics included are: (1) dates-events, (2) men-events, (3) events-men, (4) historic terms, (5) political parties, (6) divisions of history, and (7) map-study. The test can be administered in a forty-minute period.[2]

3. Starch's American History Tests, Series A. This test is based upon the facts and principles common to five modern texts. The exercises are in the form of mutilated sentences. Four duplicate forms are available.[3]

QUESTIONS AND TOPICS FOR STUDY

1. What do you think of the method used in selecting the questions for the Hahn-Lackey Geography Scale? Is it a good method? Why?
2. Can we determine what pupils should know by examining textbooks? Why? In such a subject as geography, how can you determine what pupils should know?
3. What is a "tool subject"? A "content subject"?
4. How is a score on the Hahn-Lackey Geography Scale to be interpreted?
5. Select ten questions from the Hahn-Lackey Geography Scale. In what ways do they form a better test than a list of questions you might prepare?
6. How was Harlan's American History Test made? What are its strong points? Compare it with the usual history examination.

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[1] *Seventeenth Annual Report of the City Superintendent of Schools.* (New York City, 1914–15.)

[2] Bell, J. C., and McCollum, D. F., "A Study of the Attainments of Pupils in United States History"; in *Journal of Educational Psychology* (May, 1917), vol. 8, pp. 257–74.

[3] Address Daniel Starch, University of Wisconsin, Madison, Wisconsin.

CHAPTER XI

EDUCATIONAL MEASUREMENTS AND THE TEACHER

In Chapter I evidence was presented which showed that measurements of the results of teaching, both by teachers' estimates and by examinations, were strikingly inaccurate. More accurate measurements of the results of teaching can be secured in two ways: (1) By using standardized tests. A number of these instruments have been described in the preceding chapters and the teacher has been told how to make the greatest use of the information obtained. (2) By introducing certain improvements into the making and using of examinations set by the teacher. Before presenting suggestions for making these improvements, it may be helpful to consider a question which may have occurred to some readers: *What is the value of measuring accurately the results of teaching?* The answer to this question will be presented under two heads: (1) A common-sense answer, or logical reasons; (2) experimental evidence.

(1) **Logical reasons for the value of accurate measurements by means of standardized tests.** It is a generally accepted principle that in any field of human endeavor the most efficient results are attained when one has a definite aim to work for and instruments for determining from time to time how much has been accomplished. A definite aim makes it possible for the worker to direct his efforts toward the particular things to be accomplished, instead of scattering them over an indefinite field. Instruments for measuring results make it possible for the worker to know what he has accomplished and where he needs to place greater effort and where less effort. It is also possible

for him to learn whether the materials and methods he is using are effective and which materials and methods are most effective.

This principle is the foundation of success in the business world. The merchant, manufacturer, or farmer who does not have a definite aim and who does not measure his accomplishment from time to time is most frequently a failure. Bankers measure the results of their business every day. Merchants take inventories once a year and in many cases more frequently, sometimes a partial inventory every day. They consider this procedure necessary for success.

The teacher is a manufacturer. His raw material is the children. Textbooks, school buildings, equipment, libraries, and methods and devices of teaching are the "machines" or instruments which he uses to change this raw material into the finished product or educated boys and girls who are prepared to do their part in the life of the community, State, and Nation. Without definite aims the teacher cannot plan his work effectively. He does not know, except in an indefinite or general way, what he is to do. If he has definite aims, but no instruments for measuring his results accurately, he cannot learn when he has attained his aims. Thus he is compelled to work in the dark. If he makes inaccurate measurements, but considers them accurate, he is in a still more serious situation. His efforts are almost certain to be expended unwisely.

Evidences of the lack of definite aims. It may appear to some teachers that the aims for the several grades as stated in courses of study are sufficiently definite. In the case of reading it was pointed out on pages 82–85, that oral reading was sometimes over-emphasized, while silent reading was neglected, and that in certain cases the rate of silent reading was not sufficiently emphasized. In the operations

of arithmetic the rate of work is sometimes neglected (see pages 23 and 25). Cases of irregular progress are shown in Figs. 119 and 122. When classes make irregular progress in ability to do the different types of examples, as is shown in these figures, the lack of definite aims is a contributing cause.

Another type of evidence is given in Fig. 42.[1] This figure is drawn by the method given on page 110, and shows five sets of median scores for rate and accuracy in Addition (Series B) in Grades four to eight: (1) Courtis Medians, (2) Medians for Cuyahoga County (Ohio), (3) Brook Park, (4) Rocky River, and (5) Shaker Heights. (The last three are three district schools in Cuyahoga County.) The broken line (----) connecting the small circles representing the Courtis Medians shows gradual and regular progress from grade to grade. The same condition is exhibited for Cuyahoga County as a whole, but a distinctly different situation is shown for the three schools. In the fourth grade the Brook Park School is very low in accuracy. The fifth-grade pupils show a decided gain in accuracy, but almost no progress in rate of work, while the accuracy median for the sixth grade is below that for the fifth grade. The rate of work for these three grades is approximately the same. From the sixth grade to the seventh marked progress in both rate and accuracy are shown and from the seventh to the eighth grade the progress is almost wholly in accuracy. A study of the lines representing the median scores of Rocky River and Shaker Heights reveals similar irregularities in the progress from grade to grade. This condition is probably due in a large degree to the fact that the teachers did not have definite aims for the several grades and had not

[1] This figure is taken from the *Third Annual Bulletin and School Directory of Cuyahoga County (Ohio) School District*, p. 71, by County Superintendent A. G. Yawberg.
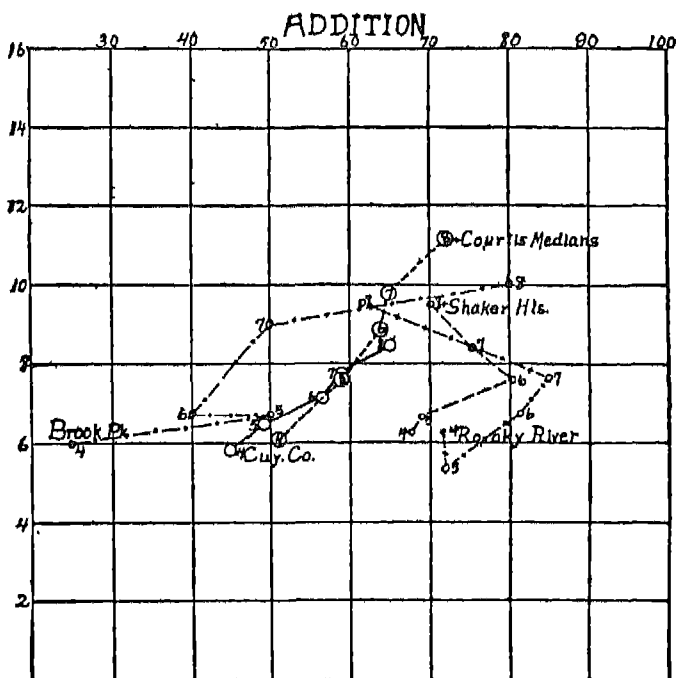
FIG. 42. MEDIANS IN SPEED AND ACCURACY IN ADDITION TEST, SERIES B, FOR PUPILS OF GRADES 4 TO 8 INCLUSIVE, SHOWING COURTIS'S MEDIANS, MEDIANS FOR CUYAHOGA COUNTY, AND FOR THREE DISTRICTS IN THE COUNTY. RATE ON VERTICAL SCALE, ACCURACY ON HORIZONTAL SCALE.

measured the results of their instruction to learn to what extent these aims were being realized.

Courses of study do not give definite working specifications for teachers. Our present courses of study represent the efforts of those occupying supervisory positions in our school systems to provide teachers with specifications for their work. How well they have succeeded is illustrated by the following quotations from typical courses of study:

Fourth Grade

Reading and Literature. Stories read and told to the class; Roman stories, American history stories relating to geography, selections from Greek and Teutonic mythology, and poems.

A few choice selections of appropriate prose and poetry are to be studied, committed to memory, and recited or dramatized. See that the pupil stands on both feet and reads smoothly and confidently. Watch the voice of pupils; use breathing exercises; and avoid harsh, strained reading. Have pupils read many selections silently, then reproduce the thought aloud in order to develop the power of gaining and expressing the thought of the text. Aim to enlarge the pupil's vocabulary, to help him master the thought content, and gain the power to read in a pleasing, well-modulated tone. Use much supplemental reading. Explain the purpose of the children's department in the Public Library, and encourage pupils to read books therefrom.

Following these general directions, the selections to be read are specified:

Third Grade: B Class

Handwriting. Daily drill, lessons five, six, or seven.[1] During the entire year these drills should be used for a few moments at the beginning of each writing lesson.

Beginning with lesson five, take the lessons in consecutive order to lesson thirty-five.

After developing a letter with the class take, from the writing book, a word beginning with the same letter and use it for practice.

If the letter is a capital, follow the word practice by using a sentence beginning with this letter. All words and sentences should be taken from the writing book.

Grade 4B. Arithmetic

Leading topics. The four fundamental processes with emphasis upon multiplication.

Review. Regularly, constantly, and from the first. The addition combinations, subtraction, reading and writing numbers, simple fractions.

---

[1] Reference to a *Manual for Teachers,* used in this school system.

Multiplication. The tables completed and made automatic. Problems with two-place multipliers. Rapid oral practice.

Division. Short division with long division brace. Rapid oral practice.

Fractions. Simple fractions and mixed numbers as needed in actual practice on concrete form problems. Largely oral and objective.

Concrete problems. One-step problems.

Applied problems. Farm products, farm marketing, farm profits.

Measures. Quart, gallon, peck, bushel, pound, ton, cord, etc., as required by applied problems.

In the fourth-grade course of study for reading, nothing is said about the rate at which a pupil is expected to read orally or the rate and degree of comprehension of silent reading. The teacher is told to "enlarge the pupils' vocabulary," but he is not told *how much* to enlarge it. In handwriting nothing is said about the rate or quality of writing. In arithmetic the multiplication tables are to be "completed and made automatic." This is indefinite because there are many degrees of automatization. What one teacher would call automatic, another would not. "Rapid oral practice" is likewise indefinite.

Definite specifications for these subjects could be given by stating the rate and quality of work expected of the pupils. For example, in handwriting the teacher would have a definite aim if he was told that fourth-grade pupils should be able to write memorized material at the rate of 56 letters per minute and with a quality of 50 as measured on the Ayres Scale. In arithmetic the aim would be definite if he were told that fourth-grade pupils should be able to write the answers to the multiplication combinations at the rate of 28 per minute. When the teacher has his aims expressed in this definite way, he still needs to measure results to learn to what extent he is realizing his aim.

(2) **Experimental evidence of the value of standardized**

tests to the teacher. Several instances of the value of standardized tests have been given in the preceding chapters. For reading, see pages 73 to 89; for arithmetic, see page 151; additional evidence is given in Figs. 43, 44, and 45. In Fig. 43 a sixth-grade teacher in a small town gave
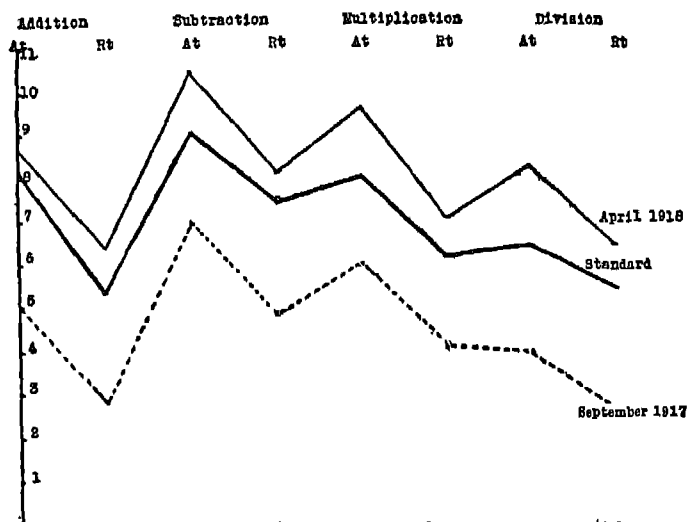
FIG 43. SHOWING THE MEDIAN SCORES OF A SIXTH-GRADE CLASS IN SEPTEMBER, 1917, AND IN APRIL, 1918, AS MEASURED BY THE COURTIS STANDARD RESEARCH TESTS IN ARITHMETIC, SERIES B

Dotted line September medians. Solid line (upper) April medians. Heavy solid line, standard median scores.

the Courtis Arithmetic Tests, Series B, in September, 1917. The condition revealed is shown by the lower line in the figure. The standards or the definite aims to be attained are represented by the heavy solid line. The results of the teacher's efforts are shown by the upper line which represents the median scores for April, 1918. This teacher knew what her pupils could do at the beginning

of the year and the standards which were to be attained. She had the satisfaction of knowing that these had been attained.

In Cleveland, Ohio, spelling was tested in May, 1915. It was again tested in May, 1917. In Fig. 44 the "efficiency" of spelling in certain of the buildings is showing for these two tests. The broken line represents the "efficiency"[1] for the test in May, 1915. The solid line represents the "efficiency" for the test in May, 1917. The significant thing in this illustration is the material improvement in spelling "efficiency" of those buildings which had low average scores in 1915. This suggests that when a teacher knows that he is not securing standard results, he is likely to increase the effectiveness of his instruction.

In the city of Boston standardized tests in arithmetic were given in 1912 in twenty-nine schools and have been given at least once each year since. In Fig. 45 these are called Group A Schools. In the Group B Schools the standardized tests in arithmetic were given first in 1913 or 1914. Group C includes those schools in which the results of instruction in arithmetic were measured for the first time in 1915. Group A represents 18,301 pupils, Group B, 15,241 pupils, and Group C, 11,836 pupils. In May, 1915, standardized tests in arithmetic (the Courtis, Series B) had been used in Group A for three consecutive years, in Group B for one or two years, and in Group C they were being given for the first time.

We have here, therefore, an opportunity to study the effect of using such tests. If the tests are helpful to the teacher, those schools in which they have been used for three

[1] "Efficiency" means here the quotient of the average score divided by the standard given by Ayres on his Spelling Scale. Since these standards are lower than the average scores in certain cases those quotients are above 100.
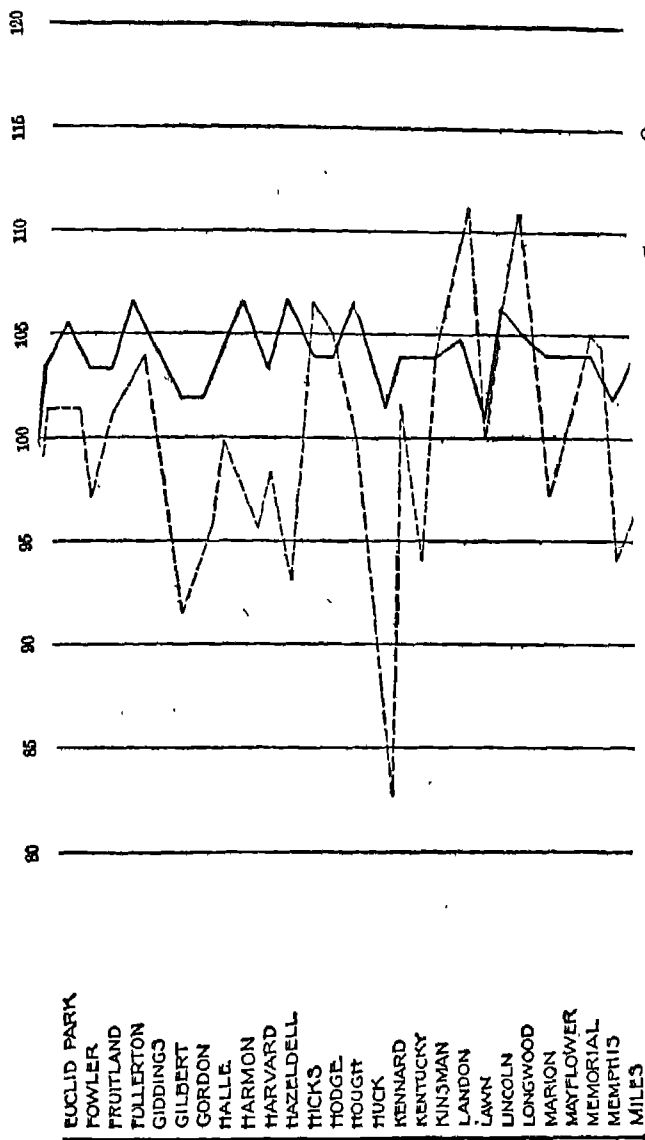
FIG. 44. SHOWING IMPROVEMENT IN SPELLING "EFFICIENCY" IN CERTAIN SCHOOLS OF CLEVELAND, OHIO

Taken from *The Results of a Spelling Test*, Bulletin no. 2, Board of Education, Division of Reference and Research, March, 1918.

years should show the best results and those in which they have been used for one or two years should stand above those in which they were given for the first time. Fig. 45
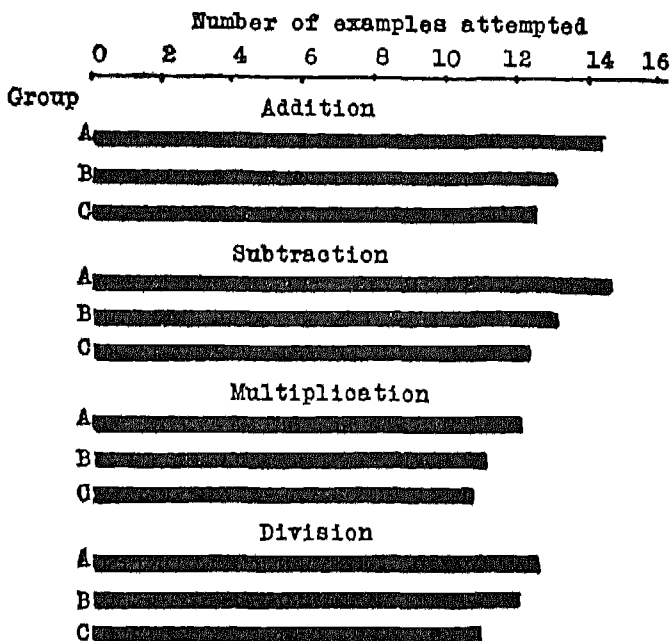
FIG. 45. SHOWING EFFECT OF CONTINUOUS USE OF COURTIS'S STANDARD RESEARCH TESTS, SERIES B, IN BOSTON, EIGHTH GRADE, 1915

Group A schools continuous use for three years. Group B schools use for one to two years. Group C schools not given until this record was secured. (*After Ballou.*)

represents the median number of examples attempted by the eighth-grade pupils in each of the three groups of schools. In every case the Group A Schools have the highest medians and the Group B Schools stand above those of Group C. The median scores for accuracy are not represented, but they show the same condition. Thus, this figure shows that

in the case of the eighth grade superior results in the operations of arithmetic are attained by those schools in which standardized tests are used. The results for the other grades in Boston are not so striking, but they furnish additional evidence that it is helpful to measure the results of instruction accurately.

Making examinations yield more accurate measurements. In Chapter I the following criticisms were made of the measurement of the results of teaching by examinations: (1) The questions cover a wide range of topics making the "grade" have no definite meaning. (2) The questions are generally not equally difficult and the same amount of credit should not be given for answering different questions. The judgment of a teacher in regard to the amount of credit which should be given for answering a question correctly is not reliable. (3) Teachers do not mark examination papers accurately. (4) The pupil's rate of work is usually neglected even in those subjects where it is important. (5) Standards are not available for interpreting the measures.

It is not possible for the teacher to eliminate entirely the defects enumerated by these criticisms, but it is possible for him to reduce them. Greater care in choosing and framing the questions will materially reduce the first defect mentioned above. Catch questions should always be avoided. Also the question should be stated so that the pupil will understand what is called for. The questions should be *important*. Unimportant facts should not be called for unless there is some particular reason for doing so.

The amount of credit to be given for answering a question correctly cannot be accurately determined, but a helpful rule to follow for questions which are approximately equal in importance is that the most credit should be given for the most difficult question and the least credit for the easiest.

Both of the above suggestions will tend to increase the

accuracy of the marking of examination papers. In addition a systematic plan will materially reduce this source of error. Kelly[1] describes the following experiment: Six fifth-grade teachers gave a uniform examination in arithmetic to their pupils. Each teacher marked the papers for her own pupils, but did not record the marks on the papers. The superintendent asked a teacher, who was unusually systematic in marking examination papers, to prepare a definite plan for marking these papers. After she had done so, she marked all of the papers in accordance with this plan. Then the teachers who had first marked the papers marked them a second time following her plan. This provided two marks for each paper by the classroom teacher, the first without following a systematic plan, and the second using a definite plan. Each of these marks was compared with the mark of the teacher who marked all of the papers. In Table XXIV the six teachers are designated by the letters A, B, C, D, E, and F. The table is read as follows: When no systematic plan was followed, teacher A marked one paper 16 to 20 points lower than the "judge," one paper 7 points lower, two papers 4 points lower, two papers 2 points lower, agreed with the "judge" on one paper, etc. The differences between the marks given when the classroom teachers had no systematic plan and when they followed such a plan are very striking. In the first instance the marks assigned by the teachers agreed with those assigned by the "judge" in only 5.5 per cent of the cases, while in the second instance they agreed in 63.5 per cent of the cases. Thus the experiment shows that with a systematic plan for marking papers, the marks will be more accurate.

The rate at which the pupil works can easily be measured in such subjects as reading, handwriting, and the operations of arithmetic. It is only necessary to place a time limit

[1] Kelly, F. J., *Teachers' Marks*, p. 84.

upon the examination such that no pupil will answer all of the questions. The number of questions answered will be a crude measure of his rate of work.

TABLE XXIV. DISTRIBUTIONS OF DIFFERENCES BETWEEN TWO SETS OF TEACHERS' MARKS ON FIFTH-GRADE ARITHMETIC PAPERS — FIRST, WITHOUT ANY EFFORT TO UNIFY THE METHODS USED, AND SECOND, BY A COMMON STANDARD (AFTER KELLY)

Range of Differences	*Without standard*							*With standard*						
	A	*B*	*C*	*D*	*E*	*F*	*Total*	*A*	*B*	*C*	*D*	*E*	*F*	*Total*
21 or more	..	..	..	..	2	..	2	..	..	..	..	..	..	..
16 to 20	1	..	..	..	1	1	3	..	..	..	..	..	..	..
15	..	..	..	..	..	2	2	..	..	..	..	..	..	..
14	..	..	..	..	..	1	1	..	..	..	..	..	..	..
13	..	..	..	..	1	2	3	..	..	..	..	..	..	..
12	..	1	..	..	1	..	2	..	..	..	..	..	..	..
11	..	..	1	..	1	2	4	..	..	1	..	..	..	1
10	..	..	..	..	..	1	1	..	1	..	..	..	..	1
9	..	1	..	..	2	1	4	..	..	..	..	..	..	..
8	..	..	..	1	3	1	5	..	..	..	..	..	..	..
7	1	1	..	1	1	1	5	..	..	..	1	..	..	1
6	..	2	..	..	1	1	4	..	..	..	..	..	..	..
5	..	1	2	1	1	2	7	..	..	..	..	..	..	..
4	2	2	2	1	1	2	10	1	..	..	..	..	1	2
3	..	4	2	1	2	2	11	..	..	1	1	1	..	3
2	2	2	1	1	1	1	8	4	1	1	3	7	1	17
1	..	5	4	3	2	4	18	2	3	4	5	1	1	16
0	1	4	4	1	1	1	12	22	30	16	16	29	26	139
1	2	5	2	2	2	1	14	5	..	2	2	1	3	13
2	6	1	3	2	3	1	16	1	1	3	..	..	..	5
3	9	..	2	..	2	..	13	..	2	2	1	..	1	6
4	5	1	4	1	5	1	17	..	2	3	3	..	..	8
5	2	3	2	2	1	..	10	..	1	1	2	..	..	4
6	1	1	..	3	2	..	7	..	..	1	1	..	..	2
7	..	1	1	6	1	..	9	..	..	..	..	..	..	..
8	..	2	1	2	..	1	6	..	..	..	..	..	..	..
9	1	..	1	2	..	..	4	..	..	..	..	..	..	..
10	1	..	..	1	..	1	3	..	..	..	..	..	..	..
11	..	1	1	..	..	..	2	..	..	..	..	..	..	..
12	1	..	..	1	..	1	3	..	..	..	..	..	..	..
13	..	1	..	..	1	1	3	..	..	..	..	..	..	..
14	..	..	..	..	..	1	1	..	..	..	..	..	..	..
15	..	..	1	1	..	..	2	..	..	..	1	..	..	1
16 to 20	..	2	..	..	..	..	2	..	..	..	..	..	..	..
21 or more	..	..	1	3	1	..	5	..	..	..	..	..	..	..
Totals	35	41	35	36	39	33	219	35	41	35	36	39	33	219
Medians	+3	0	+1	+6	−1	−4	+1							

The lack of standards can be partially remedied by having other teachers give the same examination to other pupils of the same grade. Where this is not possible, the teacher should verify what he considers a satisfactory standard by using standardized tests occasionally. If the standardized tests show a class to be near the standard, the teacher may conclude that his standard is satisfactory. If the work of the class is shown to be unsatisfactory then the teacher should conclude that his standards are too low unless her examinations have also shown the class to be doing a low grade of work.

QUESTIONS AND TOPICS FOR STUDY

1. How may examinations be made more accurate measuring instruments?
2. Do you think that examinations have functions other than that of measuring the abilities of pupils? If so, what are they?
3. Repeat the experiment described on page 218 and compare your results with those given in Table XXIV.
4. Why is a general aim not sufficient?
5. What are the objections to our present courses of study with respect to the statement of aim?
6. How can standardized tests be used in setting the aim for the teacher?
7. Criticize your course of study. How could you make use of standardized tests in improving it?
8. Why should teachers use standardized tests? (Give all of the reasons you can think of.) Do they require more time on the part of the teacher than similar tests he might prepare?

CHAPTER XII

SUMMARY

The use of standardized tests by teachers may be summarized under the following steps.

1. **Selection of a test to use.** For the most part teachers should accept the advice of experts in selecting a test. However, it is well for teachers to ask these questions about a test: (1) Has it been widely used or is it likely to be widely used in the near future? (2) How much time is required to give the test, to mark the papers, and to record the scores? These points are very important. If the test has not been widely used or there is no prospect of its wide use in the near future, reliable standards will not be available. Also the general use of a test indicates that it has been found helpful to teachers. If a test requires a large expenditure of time, a teacher is not likely to receive adequate returns for the time spent. In general a teacher should choose a test which is simple to use and which requires only a moderate amount of time.

2. **Giving the test.** In giving a test to a class the teacher should follow the directions. If this is not done, comparisons of the resulting scores with the standards will not be valid. Also the teacher should bear in mind that his purpose should not be to secure as high scores as possible, but to secure a *true* measure of the abilities of his pupils. In order to do this the pupils must not be excited or urged to work in an unnatural way.

The manner in which the test is presented to the pupils affects the scores. The purpose of measurement is defeated if the test is presented to the pupils in such a way that their

response is unnatural. For example, in handwriting, if the pupils write at an unnatural rate the quality of their handwriting will be affected.

3. **Marking the test papers.** Explicit directions and score cards are generally provided for doing this. Here also the teacher must follow the directions. If he does not, a valid comparison cannot be made with the standards. In the case of a few tests, the papers are marked by the pupils as the teacher reads the correct answers. This can be done in the case of tests in the operations of arithmetic, in certain reading tests, and in spelling. Courtis advises that this plan be followed in order to save time which may be used in the interpretation of scores. In the case of handwriting and composition, the teacher should equip himself for accurate rating of papers by systematic training.

4. **Recording the scores and calculating class scores.** Blanks for recording the scores are usually furnished with the tests. When they are at hand, this step is very simple after the teacher has had a little practice.

5. **The interpretation of scores.** In interpreting both individual and class scores, standards are necessary. Many people understand facts more easily when they are represented graphically. Hence, it is well to employ some means of graphical representation.

6. **Correction of the defects revealed by the test.** The correction of the defects revealed by the test is the culmination of the preceding steps. It is in this step that the value of standardized tests is realized. Without this step standardized tests become mere "playthings" and their use cannot be justified. The situation created is similar to that which would exist if a physician examined a patient carefully and determined the nature of his ailment, but did not prescribe any remedial treatment. In our zeal to convert teachers to the acceptance of the principle that the measurement of

certain results of instruction is possible, there has been a tendency to overlook this step. In fact some have even said that they were content to apply the tests and reveal to the teachers the shortcomings of their work. These persons would leave to the teachers the difficult problem of remedying the defects. As a result not a few teachers have failed to see in the tests anything more than a new "plaything," which they might use to secure material for a paper to read at a teachers' association or to arouse the interest of their pupils. Such teachers have expressed their approval of the tests when their pupils' scores were high, and have considered the tests unsatisfactory when the scores were low.

In order to prescribe the best corrective instruction the teacher needs to have as much information as possible. Hence, the need for diagnostic tests and for examining the test papers to learn of the pupils' errors. Diagnosis requires time, but it is justified by making possible the planning of more effective corrective instruction.

APPENDIX

A sample package of tests. It will be helpful to a teacher in reading this book to have at hand sample copies of the tests described in it. In a few cases it is almost necessary to have a copy of the test in order to understand the discussion of its use. Believing that teachers would appreciate the opportunity of being able to secure all of the tests from one address, the author has assembled packages containing one copy of the tests marked with a star below. The other tests have been either reproduced in the pages of this book or described so fully that a copy is not needed in order to understand the test. A sample package will be sent postpaid upon receipt of a post-office money order or a check for 55 cents. Do not send stamps. Coins may be sent at sender's risk. Address Walter S. Monroe, Bureau of Educational Research, University of Illinois, Urbana, Illinois.

All of the tests listed in the following table may be obtained from the author of this book by addressing him at the Bureau of Educational Research, University of Illinois, Urbana, Illinois. They may also be obtained from the respective publishers. A number of the tests are carried in stock by other distributing centers and one will find it helpful to order these tests from the distributing center in his state, if there is one. In addition to supplying the tests the Bureau will also render other important service. If their state has no Bureau, teachers may send their order to the nearest one. The prices when ordered from the Bureau are generally the same as when ordered from the publisher.

Distributing Centers

Bureau of Educational Research, University of Illinois, Urbana, Ill.

Bureau of Coöperative Research, Indiana University, Bloomington, Indiana.

Educational Extension Service, University of Iowa, Iowa City, Iowa.

Bureau of Educational Measurements and Standards, Kansas State Normal School, Emporia, Kansas.

Bureau of Coöperative Research, University of Minnesota, Minneapolis, Minnesota.

In the table below detailed information about the tests described in the preceding chapters is given. One not familiar with ordering tests should study this table carefully in order to be able to ask for just what is needed. In some cases the necessary directions and record sheets are furnished by the publisher, but this is not true in all cases. When it is not done, the one ordering must ask for the number of these accessories desired.

Very important. In ordering tests of which one copy is needed for each pupil always give the number of pupils in each grade. This is important because some of the series have different tests for the different grades.

Prices. Because the cost of both paper and printing is changing so rapidly it is not possible to quote prices for the tests listed here. However, none of these tests are published as a commercial enterprise. Therefore a purchaser may be certain that the price charged will be reasonable. If it is desired to know the price before placing an order, address the publisher or one of the distributing centers named above.

DIRECTIONS FOR ORDERING STANDARDIZED TESTS

Test	*How many tests to order*	*How many directions, record sheets, and other accessories to order*	*Used in what grades*	*Described on page of this book*	*Publisher*
*1. Monroe's Standardized Silent Reading Tests.	One copy of the test for each pupil.	All directions are printed on either the test or on the class record sheet. One record sheet is furnished with each 25 copies of the test. Additional copies may be ordered if desired.	3 to 8	22	Bureau of Educational Research, Urbana, Illinois.
*2. Courtis's Silent Reading Test No. 2.	One copy of the test for each pupil.	Folder B, Series R, contains detailed directions for giving the test and for scoring by the pupils. One copy is needed for each person giving the test. Folder D, Series R, contains detailed directions for completing the scoring, for recording the scores and for calculating class scores. One copy is needed for each person giving the test. A class record sheet for recording the scores of a class is needed for each class. A school record and graph sheet for Silent Reading No. 2 is needed for each school.	2 to 6	29	S. A. Courtis, 82 Eliot St., Detroit, Mich.

DIRECTIONS FOR ORDERING STANDARDIZED TESTS (*continued*)

Test	*How many tests to order*	*How many directions, record sheets, and other accessories to order*	*Used in what grades*	*Described on page of this book*	*Publisher*
*3. Thorndike's Visual Vocabulary Test.	One copy of the test for each pupil.	As published by the Bureau of Educational Measurements and Standards, Emporia, Kansas, all directions are printed upon the test or class record sheet. A copy of the class record sheet is furnished with each 25 copies of the test. Additional copies may be ordered if desired. As published by the Bureau of Publications, Teachers College, New York City, detailed directions are not furnished. Also a preliminary test and a class record sheet must be ordered separately.	3 to 8	36	Bureau of Educational Measurements and Standards, Emporia, Kansas; or Bureau of Publications, Teachers College, New York City.
*4. Gray's Oral Reading Test.	One copy of the test for each pupil and an extra copy for the teacher.	Directions for giving the test, for scoring the test papers, for recording the scores and for calculating class scores are printed on the class record sheet. One class record sheet should be ordered for each class.	2 to 8	39	Bureau of Educational Research, Urbana, Illinois.

DIRECTIONS FOR ORDERING STANDARDIZED TESTS (*continued*)

Test	*How many tests to order*	*How many directions, record sheets, and other accessories to order*	*Used in what grades*	*Described on page of this book*	*Publisher*
*5. Courtis's Standard Research Tests in Arithmetic, Series B.	One copy of the test for each pupil.	Folder B, Series B, contains detailed directions for giving the tests. One copy is needed for each person giving the tests. Directions for recording the scores are found on the class record sheet. One copy is needed for each class. Folder D, Series B, contains directions for calculating class scores. One copy is needed for each person giving the tests. One record sheet No. 3, and graph sheet are needed for each school. One answer card is needed for each person giving the tests.	4 to 8	97	S. A. Courtis, 82 Eliot St,, Detroit, Mich.
*6. Monroe's Diagnostic Tests in Arithmetic.	One copy of the test for each pupil.	Directions for giving the tests are printed on the tests and directions for handling the scores are printed on the class record sheet. One record sheet is furnished with each 25 tests. Additional class record sheets may be ordered if desired. One an-	Tests 1 to 11 in grades 4 to 8; Tests 12 to 16 in grades 5 to 8;	109	Bureau of Educational Research, Urbana, Illinois.

Test	*How many tests to order*	*How many directions, record sheets, and other accessories to order*	*Used in what grades*	*Described on page of this book*	*Publisher*
		swer card is furnished with each 50 tests.	Tests 17 to 21 in grades 6 to 8.		
*7. Monroe's Standardized Reasoning Tests.	One copy of the test for each pupil.	Directions for giving the test are printed on the test. Directions for marking the papers and for recording the scores are printed on the class record sheet. One copy of the record sheet is furnished with each 25 tests. Additional Class Record Sheets may be ordered if desired.	4 to 8	154	Bureau of Educational Research, Urbana, Illinois.
*8. Ayres's Spelling Scale.	One copy of the scale for each teacher.	Brief directions for using the scale are printed on it. (See page 184 of this book for additional directions.)	2 to 8	176	Russell Sage Foundation, New York City.
9. Timed-Sentence Spelling Tests.	One copy of the tests for each teacher.	Directions for using the test are printed on the test. Directions for handling the scores are printed on the class record sheet. One record sheet is furnished with each test. Addi-	3 to 8	184	Bureau of Educational Research, Urbana, Illinois.

Test	*How many tests to order*	*How many directions, record sheets, and other accessories to order*	*Used in what grades*	*Described on page of this book*	*Publisher*
		tional copies may be ordered if desired.			
*10, Ayres's Handwriting Scale, Gettysburg Edition.	One copy of the scale for each teacher.	Directions for using the scale are printed on the scale. No class record sheet is furnished by the publisher. Some of the distributing Bureaus named above have devised a class record sheet which they furnish with the scale.	2 to 8	208	Russell Sage Foundation, New York City.
11. Gray's Score Card for Handwriting.	One copy of the score card for each pupil.		2 to 8	216	Bureau of Educational Research, Urbana, Illinois.
12. Freeman's Handwriting Scale.	One copy of the scale for each teacher.	No directions for using the scale are furnished by the publisher. (See page 215.)	2 to 8	212	Houghton Mifflin Company, Boston, Mass.

DIRECTIONS FOR ORDERING STANDARDIZED TESTS (*continued*)

Test	*How many tests to order*	*How many directions, record sheets, and other accessories to order*	*Used in what grades*	*Described on page of this book*	*Publisher*
13. Willing's Composition Scale for Measuring Written Composition.	One copy of the scale for each teacher.	Complete directions for using the scale are printed on it. One copy of the class record sheet is furnished with the test. Additional copies may be ordered if desired.	4 to 8	235	Bureau of Educational Research, Urbana, Illinois.
14. Nassau County Supplement to the Hillegas Scale.	One copy of the scale for each teacher.	No directions for using the scale are furnished with the scale by the publishers. There is also no class record sheet.	4 to 8	243	Bureau of Publications, Teachers College, New York City.
*15. Charters's Diagnostic Test in Language and Grammar for Pronouns.	One copy of the test for each pupil.	Directions for giving the test are printed on the test. Directions for marking the papers and for handling the scores are printed on the class record sheet. One class record sheet is furnished with every 25 copies of the test. Additional copies may be ordered if desired.	7 and 8	245	Bureau of Educational Research, University of Illinois, Urbana, Ill.

DIRECTIONS FOR ORDERING STANDARDIZED TESTS (*continued*)

Test	*How many tests to order*	*How many directions, record sheets, and other accessories to order*	*Used in what grades*	*Described on page of this book*	*Publisher*
*15a. Charters's Diagnostic Language Test	One copy of the test for each pupil.	Directions for giving the test are printed on the test. Directions for marking the papers and for handling the scores are printed on the class record sheet. One class record sheet is furnished with every 25 copies of the test. Additional copies may be ordered if desired.	3 to 8	245	Bureau of Educational Research, University of Illinois, Urbana, Ill.
16. Starch's Punctuation Scale.	One copy of the scale for each pupil.	Directions are given on a separate sheet. No class record sheet is furnished by the publisher.	5 to 8	248	Daniel Starch, University of Wisconsin, Madison, Wis.
*17. Courtis's Standard Tests in Geography for States and important places.	One copy of the test for each pupil.		4 to 8	256	S. A. Courtis, 82 Eliot St., Detroit, Mich.

DIRECTIONS FOR ORDERING STANDARDIZED TESTS (*continued*)

Test	*How many tests to order*	*How many directions, record sheets, and other accessories to order*	*Used in what grades*	*Described on page of this book*	*Publisher*
18. Hahn-Lackey Geography Scale.	One copy of the scale for each teacher.	Brief directions for using the scale are printed on it. Explicit directions for scoring the test papers are printed separately and furnished with the scale. There is no class record sheet.	3 to 8	258	H. H. Hahn, State Normal School, Wayne, Neb.
*19. Harlan's Test of Information in American History.	One copy of the test for each pupil.	Directions for giving the test, for scoring the papers and for handling the scores are printed separately. One copy is needed for each person giving the test. Class Record Sheet, one copy is needed for each class.	7 and 8	262	Bureau of Educational Research, Urbana, Illinois.

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